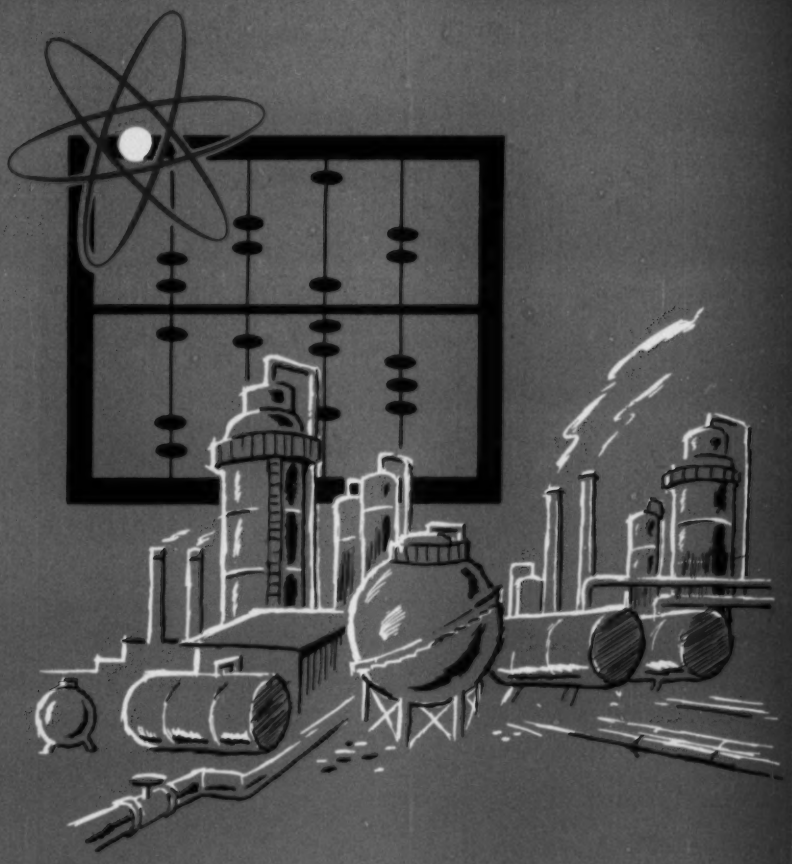
AUTOMATION

DECEMBER 1957



Computer Control

CLOSES THE LOOP

The Magazine of Automatic Operations

- **Making Teflon Insulated Wire**
- **Numerical Control**
- **Electrical Assembly by Resistance Welding**
- **Hydraulic Valves**

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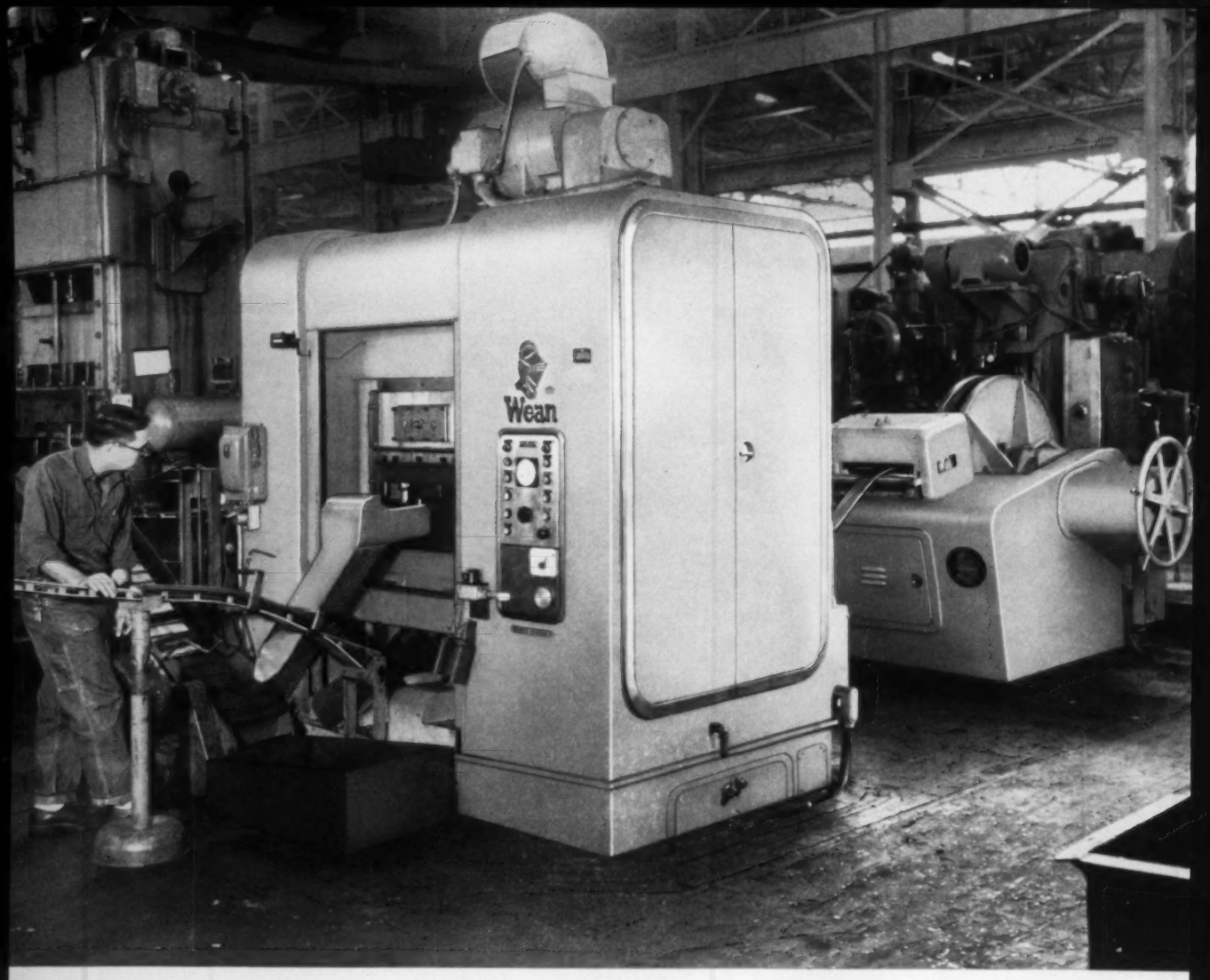
A PENTON PUBLICATION



One Wean "Flying Press"

replaces two conventional presses

THE 100 x 24 x 36 WEAN FLYING-PRESS, above, is turning out transmission vanes in the plant of a major automobile manufacturer. The vanes, 3¾″ long by 1⅝″ wide, are blanked out of .042″ steel strip and formed through a seven stage die. Previously produced by two conventional presses, each operating at 154 S.P.M., their combined production will be more than equaled by this single Wean Flying-Press operating at 350 S.P.M. Typical of the specialized engineering which Wean applies in "tailoring" press and auxiliary units to a specific operation is the ingenious mechanism which receives the vanes from the press and nest-stacks them for maximum ease of handling.

But here is the important fact to cost conscious manufacturers . . . this Wean Flying-Press will materially reduce production costs: since only half the number of press units are now required for this operation, operating and maintenance costs are cut by more than 50%—supervision and handling requirements are proportionately reduced—and, less production space is required.

In addition to increased production rates, the Flying-Press incorporates many other cost saving advantages, too. But get the complete story by writing today for your copy of the Wean Flying-Press brochure.

475

Wean Equipment Corporation
CLEVELAND 17, OHIO

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In the most forward position

...Hannifin valves

Our "NE" valve—one of several Hannifin 4-way directional air control valves. Ask your Hannifin man when to use it.

Persistent research is bringing Hannifin valves to the most forward position in the field of pneumatic controls. These valves are opening up new areas of progress for sequential automatic production.

The Hannifin valves you buy today incorporate the very latest results of never-ending testing and development. Versatility of application and dependability of operation are winning them their position of leadership.

See your Hannifin man. Find out for yourself why Hannifin air control valves are so rapidly becoming first choice for automatic operation.

AIR CONTROL

HANNIFIN

VALVES

For this complete catalog showing all the Hannifin directional air control valves, write to Hannifin Company, 541 South Wolf Road, Des Plaines, Illinois.

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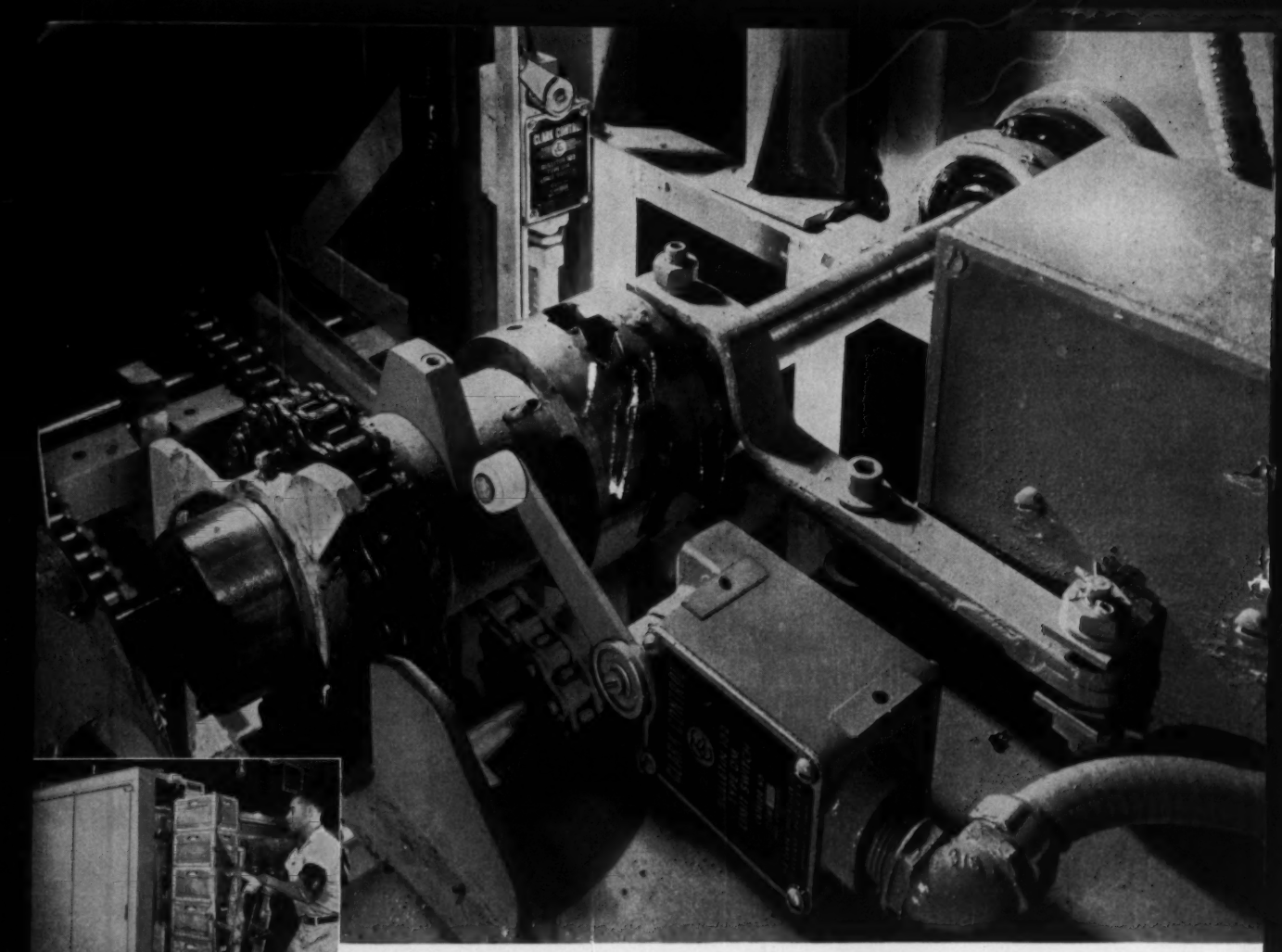
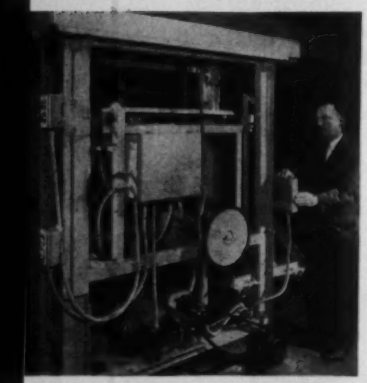


Large illustration above shows a section of the Worcester Automatic Stacker. Two of the six Clark Limit Switches are visible.

Photo top left shows stacked cases being removed from the machine in a dairy.



Robert St. Jean, President of Worcester Automatic Machine Company demonstrates the operation of the Stacker. Side panels have been removed to show working mechanism. Entire operation is automatic.

In addition to the six Clark Limit Switches, the stacker also uses a Clark Bulletin 6013 motor starter (shown in enclosure) and three Clark Bulletin 100 Push Button Stations, one of which is seen at left.

Stacking Machine designed for Ruggedness and Dependability uses CLARK Type "DM" Limit Switches

● Worcester Automatic Machine Company manufactures highly efficient case stackers for dairies and bottling plants. A basic design requirement for these machines is extreme ruggedness to assure dependable, continuous, automatic operation. Limit Switches controlling the sequencing of horizontal and vertical movement of the cases must be accurate and must have the durability to withstand thousands of operations per day, day in and day out.

Robert St. Jean, President of the company and designer of the machine says: "We selected Clark Type "DM" Limit Switches because they match the ruggedness built into the rest of the machine. We like, particularly, their sturdy die-cast case and their smooth, positive snap action resulting from the use of nylon for rollers and latch parts. There are six limit switches—all Clark—on each stacker. In spite of the pounding they take, failures have been negligible".

Clark Type "DM" Heavy-duty Limit Switches are available with a wide selection of mounting arrangements and operating levers to meet any requirement.
Write for Bulletin 102 DM

The CLARK CONTROLLER Co.
Everything Under Control • 1146 East 152nd Street • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS LIMITED • MAIN OFFICE AND PLANT: TORONTO

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DECEMBER 1957
Vol. 4—No. 12

AUTOMATION

A PENTON PUBLICATION

The Magazine of Automatic Operations

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automation outlook

NEEDED: SYSTEMS ENGINEERS

". . . the systems engineer is the man who is generally concerned with the over-all planning, design, testing, and the production of today's automatic and semiautomatic systems. The first need for this kind of engineering appeared when it was discovered that satisfactory components do not necessarily combine to produce a satisfactory system. Even though individual components may satisfy all specifications, very often the system as a whole will not work. Complexity of our modern machine assemblages has created the need for systems design and systems engineering . . ."—*Alphonse Chapanis, professor of psychology and industrial engineering, Johns Hopkins University.*

COMMON WORDS

". . . mechanization and automation are common words in the U. S. soft coal industry . . . Coal has undergone a vast transformation in a comparatively brief span of years. No longer is reliance placed on sheer human and animal muscle power. The age of the miner needing only a pick and a strong back is gone. Today complex machines provide the muscle, and the miner is a skilled operator. Mechanization of coal has been an enormously expensive proposition. It has been carried on during years in which coal's profits have been grossly inadequate—and in many instances have been non-existent. But, despite a bleak profit picture, the industry has lost neither vigor nor vision. To meet the competition with other fuels, it has done everything in its power to lower costs and make its production methods more efficient. And only by doing that has it been possible for coal to bear its extremely high wage and other payroll costs . . ."—*Industrial News Review, Sept. 15, 1957.*

UNTAPPED POTENTIAL

". . . even with the recent acceleration toward automation witnessed in recent years, experts will tell you that American industry is still woefully behind where it should and could be in modernization of its production machinery. With built-in high labor costs, times of recession offer a great potential for improvement in labor saving machinery. Therefore, we are directing more and more attention to the fields of hydraulics and electronic, pneumatic and other related controls. We have a $1 million program for doubling our hydraulic research facilities. Furthermore, we are not limiting our efforts to research and growth from within. We would be delighted to probe very thoroughly any attractive acquisition opportunities in this field . . ."—*Kempton Dunn, president, American Brake Shoe Co.*

SYSTEMS APPROACH ESSENTIAL

". . . it is pertinent to an understanding of basic approaches to automation to note that the search for alternate means of automatically affixing wires to terminals has resulted from a basic analytical study of the requirements of the manufacturing operations involved. Automatic machines and processes can be successfully developed only in terms of the universe or system prescribed both by apparatus designs and process requirements. In automation development the systems approach is essential . . ."—*Chester A. Purdy, superintendent of development engineering, Hawthorne Works, Western Electric Co. Inc.,* *see page 61.*

AUTOMATION

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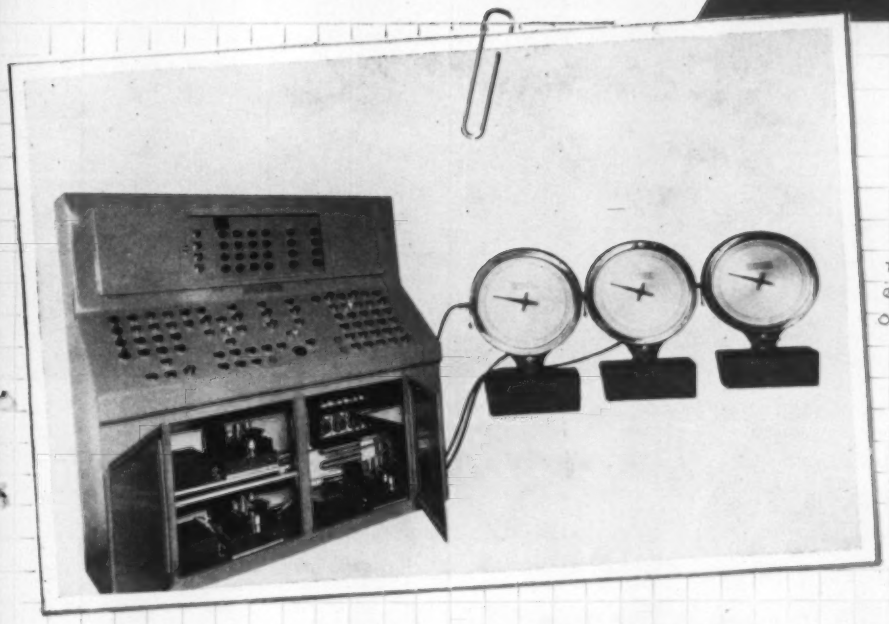
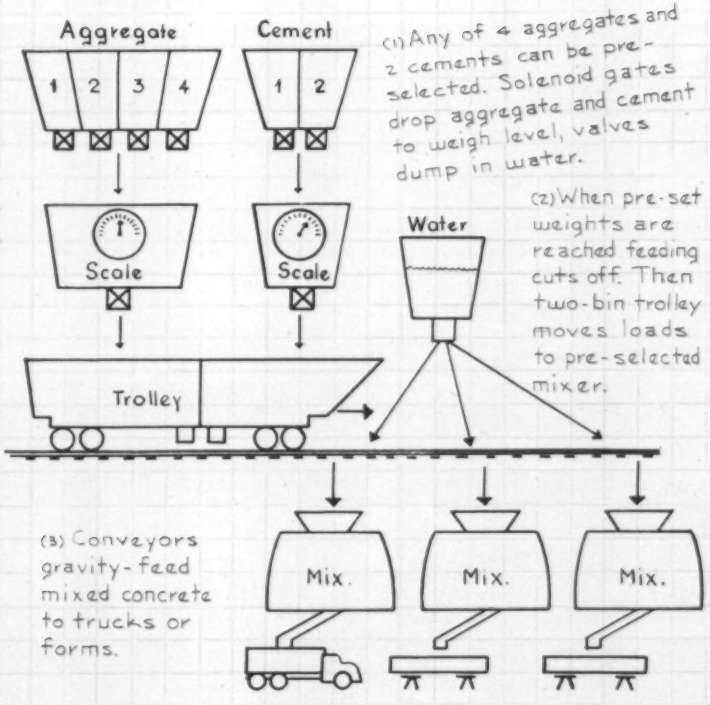


Nerve center for concrete mixing plant is the Gemco select-weigh -batch control console. It supervises operations on five floors of 300' long plant -- enables aggregate weighing to one part in 5,000.

GEMCO SR* PUSH-BUTTON BATCHING

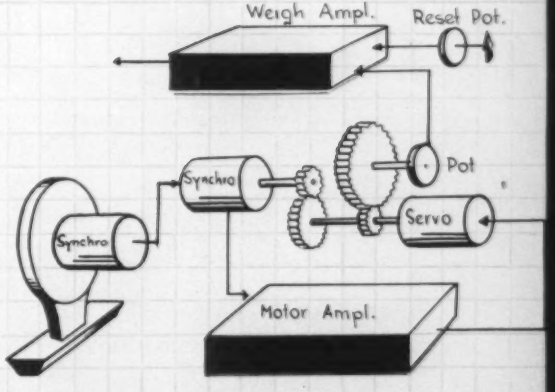


(1) Any of 4 aggregates and 2 cements can be pre-selected. Solenoid gates drop aggregate and cement to weigh level, valves dump in water.

(2) When pre-set weights are reached feeding cuts off. Then two-bin trolley moves loads to pre-selected mixer.

(3) Conveyors gravity-feed mixed concrete to trucks or forms.

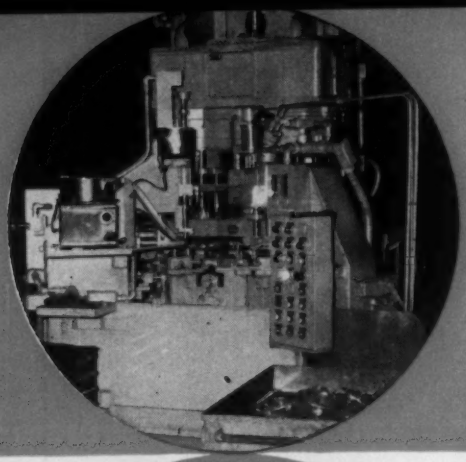
(4)* Gemco-designed saturable reactor servo system controls weights. Synchro on back of scale compares actual with pre-set weight. When correct quantity is reached, gates close and control circuit starts dumping and mixing.



(5) Automatic processing, handling and machining have been a Gemco control specialty for a dozen years. Why not find out how this experience can help you? Let us have your needs.

Circle 656 on Page 17

GEMCO
CUSTOM CONTROLS
GEMCO ELECTRIC COMPANY
25681 W. 8 Mile Rd. • Detroit 4), Mich.



Two sizes of motor end-plates are assembled, bored, drilled and tapped in a Natco 3-Way Machine.

At Wagner Electric Corporation

One Natco

NATCO

Assembles, Bores, Drills and Taps... Reduces Labor Cost 70% On Small Motor End-Plates

This Natco combination assembly and multi-drilling machine presses a bearing sleeve into the end-plate, rough and finish bores the outside bearing-cap hole, drills an oiler hole at an angle, drills four (4) thru-bolt holes, and drills and taps two (2) 8x32 cover plate holes. *Production is 170 pieces per hour.*

This Natco accommodates two sizes of motor end-plates without changes in the basic rotary-table tooling. In addition to this important versatility the engineers at Wagner Electric point out these other advantages:

- *one operator* controls the assembly and machining from one station.
- *work scheduling* is simplified due to the short machine cycle.
- *in-process inventory* can be kept at a minimum because of high production rate.
- *floor space* is made available for other operations.

Natcos perform all kinds of drilling, boring, facing and tapping jobs in every conceivable combination and sequence.

Ask the Natco Field Engineer about the newly perfected tape control systems for Natco production tools.

National Automatic Tool Company, Inc.

Richmond, Indiana ***Multi-spindle drilling, boring and tapping machines. Special machines for automatic production.***

Call Natco Offices in Chicago, Detroit, New York, Buffalo, Philadelphia, Cleveland, Los Angeles; distributors in other cities.

Circle 657 on Page 17

New Model D Single Dial CompAIRator. Available with instrument mounted gaging; or for remote connection to machining operations for in-process or post-process gaging.

New!

New Model E. For the first time, a low-cost version of standard Taft-Peirce circuits so you can cut costs by using air gaging for many more inspection operations. Has external tolerance hands and compact cabinet. Same accuracy, same dependability — the biggest air gage value on the market.

HIGH PERFORMANCE Air Gage Line

...the TAFT-PEIRCE Model D CompAIRator

Here's another big improvement in air gaging. The well-known CompAIRator has a completely new functional design that gives you 3 big advantages: — makes air gaging easier to read, easier to use and easier to trust!

EASY TO READ — Special visor and slanted face cuts glare and reduces parallax — speeds the gaging operation. Dial has full 180° linearity.

EASY TO SET UP AND USE — Zero and range setting knobs are within easy reach of the operator. Plus, compact chassis, and simplified dial and magnification changes. The Model D can be set and used at any angle, moved easily because it's light. Can be racked or modulized.

EASY TO TRUST — Yes, you can place full confidence in the new design because it uses the proven T-P Velocity-Venturi Circuit. Repeats readings without variation, has exceptional speed of response and is readily adaptable to many special uses, including wide tolerance gaging.

Modernize your gaging with this new CompAIRator. Or, ask a Taft-Peirce representative to demonstrate the new T-P CompAIRator — you'll be amazed at the performance.

TAKE IT TO TAFT-PEIRCE

THE TAFT-PEIRCE MANUFACTURING CO., WOONSOCKET, R. I.

T-P Means TOP Precision

Circle 658 on Page 17

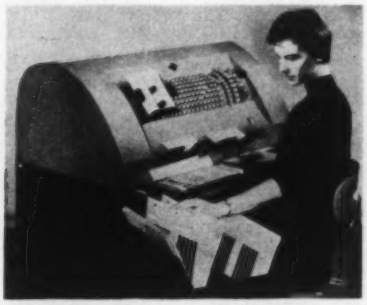
AUTOMATION news

Today's events and developments in the field of automation

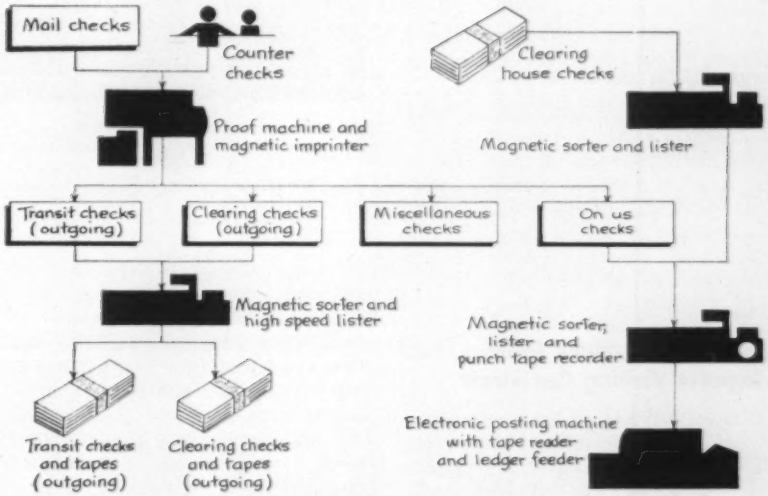
Automation Program For Banks To Streamline Check Handling

AUTOMATION program for providing equipment to modernize bank operating procedures has been announced by National Cash Register Co. The program will allow banks of all sizes to go through progressive stages of automation as the new equipment is made available. By 1960 the complete system of automatic equipment will be on the market, and a bank will have been able to make the complete transition from manual to automatic operations.

The NCR system is designed to fit in with existing methods and equipment. The first two basic units to be provided will be an electronic bank posting machine and a high speed magnetic character sorter. As a bank increases its need for automation, NCR will furnish add-on units for use with the basic units. By the time a complete system has been installed, checks and other bank documents will be processed almost automatically from the time of receipt by mail, over the counter, or through clearing houses until they are posted to individual accounts and statements mailed.



ELECTRONIC posting machine is a basic unit of the NCR automation program. The unit produces conventional bank records in detail—statement, ledger, and journal—in one posting operation. When the new record feeder device and the punch tape reader are available in 1960, the machine will automatically post accounts without the need for an operator.


Mail checks
Counter checks
Clearing house checks
Proof machine and magnetic imprinter
Magnetic sorter and lister
Transit checks (outgoing)
Clearing checks (outgoing)
Miscellaneous checks
On us checks
Magnetic sorter and high speed lister
Magnetic sorter, lister and punch tape recorder
Transit checks and tapes (outgoing)
Clearing checks and tapes (outgoing)
Electronic posting machine with tape reader and ledger feeder

FLOW chart of NCR proposed program shows a fully automated check handling system. All checks received by mail or over the counter are processed through a proof machine which magnetically imprints dollar amounts. Outgoing checks (transit and to clearing) are then sorted and listed automtically before distribution to other banks. The banks own checks, together with incoming checks from clearing houses, are sorted to accounts and listed for bookkeeper controls. At the same time a punch tape records data which is next fed into the electronic posting machine by the tape reader. A ledger feeder device feeds statements automatically, and the posting machine posts all accounts without need for an operator.

The following components are planned in the NCR system: An electronic bank posting machine, a high-speed magnetic character sorter, a magnetic character imprinter, a listing attachment to the sorter, a paper punch tape recorder, a punched paper tape reader, and an automatic statement-ledger feeder.

The electronic bank posting machine was introduced by NCR late last year and has been installed in many banks. A magnetic character sorter, jointly produced by Pitney-Bowes and NCR, will be ready for delivery next year. The 12 pocket sorter will be able to read each check's account number, amount, ABA number, and Federal Reserve routing symbol from magnetic characters imprinted on the check. In 1959 a magnetic imprinter will be available for attachment to existing proof machines, and it will be used to imprint dollar amounts on each check as a part of normal proof operations. A listing attachment and punch tape recorder for use with the magnetic sorter will be ready for delivery in 1960. The lister will automatically list items as they are sorted, and the punch tape recorder will make a tape of the items for use in the electronic posting machine. Also available in 1960 will be an automatic statement-

ledger feeding device and a punch tape reader to make the electronic posting machine completely automatic.

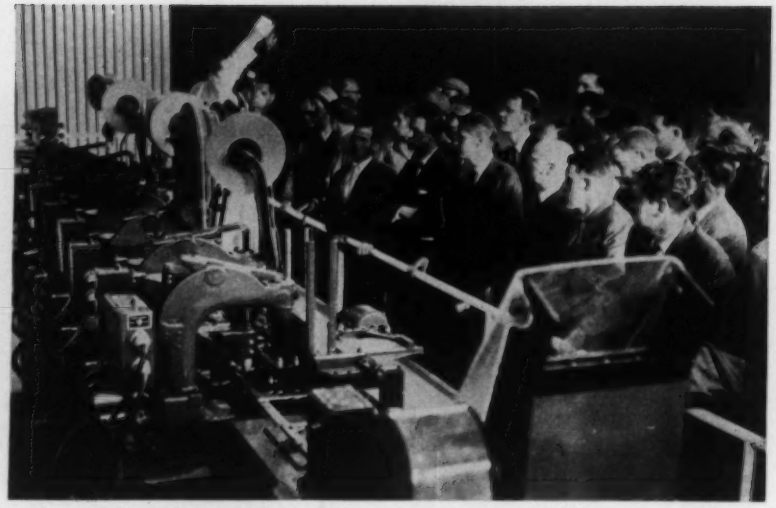
The NCR automation plan can be used by any bank for internal check handling as soon as its checks are preprinted with magnetic code numbers for accounts. Gradually, as the common language system of magnetic characters is adopted by more banks, the system will provide automatic sorting and listing of most outgoing clearing and transit checks at a high rate of speed in addition to processing internal checks. When the transition to automation is complete in a large number of banks, incoming mail will be able to be proved automatically at a rate of 750 items per minute instead of the current rate of 1000 per hour.

European Economy Gains Impress Visiting Consultant

COMMENTING on a three months tour of branch offices in Europe, **Paul N. Weil,** president of Pegasus International Corp., foreign trade consultants, said he had been particularly impressed by the progress made in all sectors of Europe's economy. This progress, Mr. Weil feels, has "stimulated a greater demand for American production methods and 'know-how', for patents, licenses, and research and development experience." Equally, foreign firms are eager to share skills with interested American firms on a reciprocal basis. "A growing number of European firms —both large and small—are manifestly interested in importing 'know-how' and exporting their own."

With their plants rebuilt and modernized, Europe's industry is spending ever growing amounts of money on research and development. This research, reports Mr. Weil, has reached significant proportions which make it imperative for American companies to keep abreast of this progress.

In his contacts with industry leaders abroad, Mr. Weil noted that their personal outlook had changed considerably. A criticism heard frequently from owners of small companies in Europe, was that valid proposals for collaborating with smaller American firms—which were perfectly feasible and did not involve any great investment — were frequently rejected outright. The reason for this, it was felt, was that either the smaller American firms have developed an "inferiority complex" so far as foreign business is concerned, or that the modest size of the initial financial return obscured for the American company an appreciation of the possible long-term gains.



LARGEST trade fair in Northern Europe was held during early September in Stockholm, Sweden. The theme of the U.S. Government Exhibit in the American Pavilion at the St. Erik's International Trade Fair was "Automation At Work". Many U.S. industries loaned equipment and machines for the exhibit. An automatic assembly machine, shown demonstrating the assembly of components to printed circuits, attracted considerable attention and was loaned and operated by United Shoe Machinery Corp.

Speech Converted Into Digits For Wire Transmission Studies

EQUIPMENT designed at Bell Telephone Laboratories and developed by the Modac Div. of Airborne Instruments Laboratory now permits Bell researchers to prove complex theories of speech transmission without building expensive test models. The transmission of speech over wires is one of the most challenging problems in the field of engineering. The Bell Laboratories are continually faced with the problem of how best to test all of the variables of distance, time and performance characteristics of present-known equipment and anticipate their effect on proposed changes.

Bell Laboratories researchers developed a theory involving equipment that could convert their proposed changes into computer information at a great saving of time and money in testing the changes. As a result, the Record and Playback Unit was conceived and is being manufactured by Modac Div. of Airborne Instruments Laboratory. This equipment reduces experimental theories on speech and speech systems to a magnetic tape and evaluates them by actually examining electrically the synthesized output of the IBM computer, as different variables and engineering concepts are introduced.

Joseph D. Mountain, Director of Modac, in explaining the equipment, stated, "The Modac equipment offers a method of testing theories that is faster and less expensive than any other method and that is of almost universal application. In sound research, exact conditions of the proposed telephone circuit—the functions of the existing equipment plus the individual function of the equipment to be introduced—are fed onto magnetic tapes that record all of the functions as electronic impulses. The Modac equipment to-

Look to Skinner in '58

for NEW answers to your control "puzzles"

Coming soon — several completely new solenoid valve lines loaded with such features as...

- **Lower prices**
- **Greater capacities** • **Higher pressures**
- **Long life expectancy—millions of cycles**
- **Diversified applications**
- **Wide selection of media handling**

And these are but a few of the many new advantages of Skinner's new solenoid valves. As always, of course, they'll be strictly manufactured to Skinner's highest-quality engineering standards.

Look for the announcements of Skinner's new valve lines in these pages throughout 1958. For advance information, write Dept. 32D.

Circle 659 on Page 17

Most important, these new valves will give you performance and applications that heretofore have not been possible!

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION

NEW BRITAIN CONNECTICUT

105 EDGEWOOD AVENUE

gether with a converter combines the impulses into digits, which it feeds to the computer. In the computer, the digits are run through a myriad of equations simulating the circuit, and a final answer—in numerical form—is produced. This answer is then fed back into Modac Equipment where it is converted into electronic impulses which exactly duplicate those of the proposed new circuitry. The machine then reproduces the voice through a speaker, exactly as it would sound if the voice had traveled any proposed distance."

PURCHASE of Sidney Machine Tool Co. by Buhr Machine Tool Co. has been announced by **Joseph H. Buhr,** president of Buhr. Sidney Machine Tool will operate as a wholly-owned subsidiary of Buhr and will continue to manufacture heavy duty lathes and coil winders.

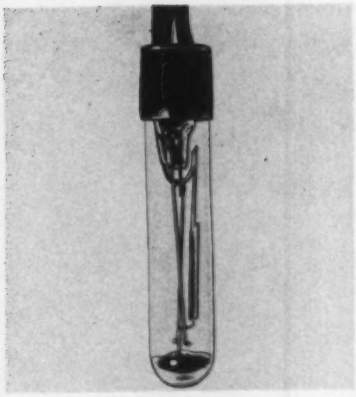
X-ray Pulses Gage Film and Foil Thickness

STRIPS of film or foil moving at speeds up to 6,000 fpm can be measured for millionths-of-an-inch deviation in thinness by a Measuray x-ray gage developed by Sheffield Corp.

Low intensity x-ray pulses, emitted 60 to 600 times per second, permit instantaneous measurement of thickness of foils made of aluminum, steel, copper and brass, and plastic film. Each x-ray pulse provides an individual and independent gage reading of fast-moving strip stock as thin as 0.0002 in.

With its Measuray x-ray gage, Sheffield departs from the usual method of x-ray gaging which averages thickness readings over a number of cycles. The new x-ray gage assures instantaneous and accurate measurement at the precise point of gaging.

A reading can be taken every 1/3 inch on a film or foil strip moving at 1000 fpm as the instrument emits 600 x-ray pulses per second. At this rate the new gage takes 36,000 individual readings each minute.



MAGNETICALLY actuated mercury switch has been announced by Hamlin Inc. The single-pole double-throw 1 amp 115v ac switch is hermetically sealed in hydrogen atmosphere with platinum contacts wetted in clean mercury. Up to 60 operations per second are possible. Maintenance of the switch is eliminated as contacts cannot wear down, get dirty or stick by locking or welding.

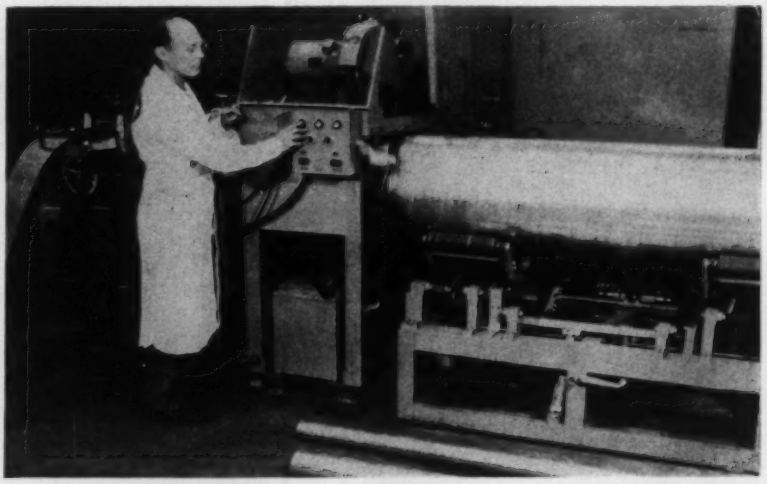
High-speed electronic counting, marketing and sorting devices can be hooked up with the new x-ray gage because of its ultra-fast cycle. It will also accommodate automatic strip thickness controllers, recorders, totalizers, production analyzers and other accessory devices.

Thickness is measured by the new instrument without contacting or marring the film or foil materials. X-ray pulses are flashed at a strip moving between the scanning unit's emitter and receiver. The receiver detects and amplifies the amount of x-ray energy that gets through the moving strip. Because thicker strips absorb more x-ray energy, the new instrument is able to measure changes in thickness. Deviation from nominal size is given in readings of per cent plus or minus, or in millionths of an inch.

Power Plant To Utilize Automatic Instrumentation

AUTOMATIC control of a new 200,000 kw unit of the Sterlington steam electric station of the Louisiana Power and Light Co. is being accomplished by the installation of a Daystrom Operational Information System produced by the Systems Div. of the Controlonics Group, Daystrom Inc.

The Operational Information System will cover measurements at 350 points throughout the power plant. Of this total, 100 points will be automatically logged every hour. The system provides continuous scanning of the remaining 250 points which will record on a separate printer and actuate



CYLINDRICAL ducts for carrying high pressure air at high velocity are now being spirally wound from a continuous strip of thin gage metal on a machine developed by Carrier Corp. An automatic cut-off saw slices the duct into desired lengths during the continuous process. One man operates the machine from the small control panel, and duct sizes from 3 to 25 inches can be made automatically by manipulation of controls.

ANNOUNCING!

VICKERS® New ¼" Temperature and Pressure Compensated FLOW CONTROL VALVE

ANOTHER VICKERS FIRST

FOR OPERATING PRESSURES UP TO 2000 psi

For years the Machine Tool Industry has been asking for a combination Temperature and Pressure Compensated Flow Control Valve to insure CONSTANT FEED RATES. Now for the first time it is available as a production unit at a reasonable price.

Check THESE EXCLUSIVE FEATURES that mean Optimum Tool Life and Better Work Finish:

- **TEMPERATURE COMPENSATED**
  Constant feed rates all day long with same throttle setting because throttle automatically compensates for changes in oil temperature. The compensator mechanism is simple in design and durable.
- **PRESSURE COMPENSATED**
  Constant feed rate throughout entire cycle because built-in pressure hydrostat automatically compensates for load changes.
- **SINGLE THROTTLE COMPLETE RANGE ADJUSTMENT**
  Greater flexibility because valve is adjustable within entire flow range of 5 to 1000 cubic inches per minute.
- **REVERSE FREE FLOW AS STANDARD FEATURE**
  A standard feature which permits reverse free flow (up to 1400 cu. in. per min.) from outlet to inlet port by-passing control elements.
- **TAMPER-PROOF ADJUSTMENT**
  Retension of original feed rate is assured because a set screw prevents inadvertent throttle movement and a cover over the set screw can be locked in place.
- **INTERCHANGEABLE**
  This new valve replaces 12 previous models and it is interchangeable with all of them, also the drain connection is eliminated on the new valve to simplify piping.
- **GREATER ECONOMY**
  No need to stock several valves for wide range of flow rates. Drain connection is eliminated, piping costs are reduced.
- **MAXIMUM RELIABILITY AND ACCURACY**
  Design of temperature and pressure control components assures maximum circuit reliability and extreme accuracy of feed through a range of 5 to 1000 cubic inches per minute.

FOR ADDITIONAL INFORMATION SEND FOR I-195040

7945

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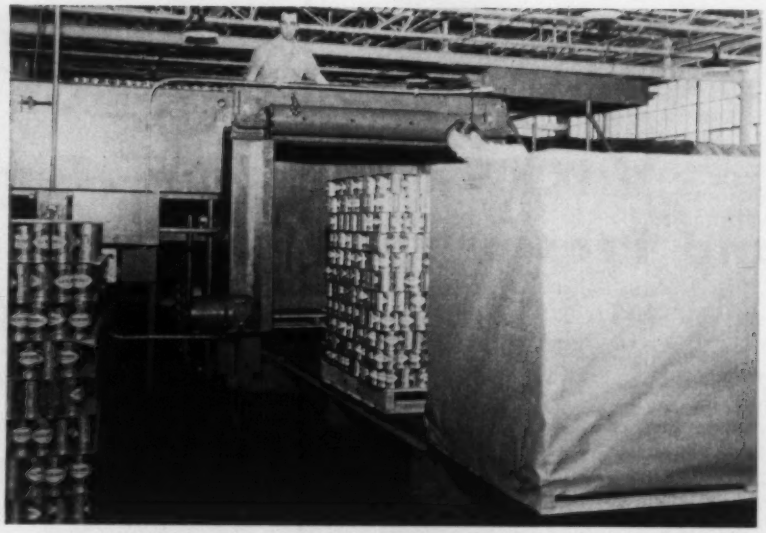
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 660 on Page 17

an alarm if they exceed set limits. The operator can select any or all 350 points for readings, thus all significant information on the operation of the plant will be presented at one central point.

The installation will provide a high degree of accuracy and reliability. All electronic components of this system are solid state; transistors rather than vacuum tubes are used throughout; all relays used are of the mercury wetted computer type. The equipment will include the first industrial use of a transistorized digital computer and the DADIT, a transistorized analog to digital converter.

The use of solid state elements throughout the system eliminates vacuum tubes, which are subject to sudden failure and are the least reliable elements of conventional equipment. Programming flexibility is another major feature of the system. Pinboards and patchboards used for programming in conventional equipment are completely eliminated and programming is accomplished by punching paper tape for all instructions such as scanning sequences, sampling schedules, linearizations, scaling factors, alarm levels and conditions, temperature and pressure values for flow compensation and computation instructions. The information is stored magnetically in the computer and can be varied at will without requiring physical changes in the equipment.



FACILITIES for bulk palletization of beer cans for shipment to breweries have been installed at the new Detroit beer and soft drink can plant of American Can Co. Eight-ounce beer cans are fed from the production line at the upper left at 500 cans per minute, are electronically counted, and are guided onto the pallets by the operator. Each layer of 352 beer cans is separated by paper sheets, and the pallet automatically drops to receive the next layer. After the pallet is filled with 3872 cans, complete unit is packaged with Kraft paper for shipment.

Non-Management Technical Salaries Rise 5.9% In 1957

SALARY levels of engineering, scientific, and administrative employees in American industry rose an average of 5.9 per cent between June, 1956, and June, 1957, according to a survey recently distributed by the American Management Association. This increase is appreciably lower than the 8.6 per cent average salary rise reported for the same group for the year ended in June, 1956.

The study covered rates and ranges of pay for 33,797 employees engaged in 58 major engineering, scientific, and administrative activities in 263 companies located in the United States and 17 in Canada. The American companies employ nearly 32,000 of the individuals included in the sample, and comparisons drawn with the previous year apply only to the United States.

Percentage salary increases varied for individual specialties. The maximum increase shown was for quality control engineers, who averaged 7.9 per cent in raises. Some electrical and mechanical engineers increased their compensation by an average of 7.5 per cent. The smallest increases shown were for systems and procedures analysts at 3.8 per cent.

Median annual salaries currently paid to engineers in all fields of activity ranged from about $5400 for engineers with bachelor of science degrees plus up to one year of experience to approximately $13,100 for engineers of long experience responsible for planning, conducting, and supervising assignments including large and important projects. The results of the survey showed that for some specific types of engineering jobs individual salaries are as high as $20,000 a year.

Salaries of chemists, mathematicians, physicists, and other scientists ranged from a median of $5400 a year at the beginning level to a median of $14,000 at the highest level. Median salaries of administrative employees such as staff accountants, internal auditors, and systems and procedures analysts generally fall between $5100 and $10,000 a year. Those for corporate attorneys range from $6300 to $16,500.

Only between 15 and 20 per cent of the employees covered in the survey receive bonuses, which varied between 5 and 15 per cent of base pay. Slightly more than half of the companies surveyed pay overtime to administrative and technical people for regularly scheduled hours in excess of the normal work week. Three-fourths use systematic or formal job evaluation methods in establishing rates and ranges of compensation for administrative and technical positions.

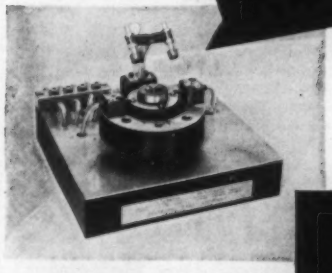
Metals Joining Technique

CHEMICAL joining of similar and dissimilar nonferrous metals is now possible by use of a new material, called InterAct, developed by Intertectics Inc.

Speed Inspection
OF PRODUCTION PARTS!

NEW **DEARBORNAIRE**

MULTIPLE COLUMN AIR GAGING INSTRUMENTS



Special Air Gaging Fixtures designed and built to meet your particular application requirements. Complete engineering service available upon request.

Send part print showing all dimensions to be checked and tolerances required for prompt quotation and delivery.

To speed inspection of production parts, new Dearbornaire air gaging instruments are now offered in multiple column units designed to permit more accurate simultaneous checking of as many dimensions as may be required for a given part. What's more, each unit incorporates all of the advanced design features which have made Dearbornaire the most practical, most versatile column type instrument ever produced . . .

- New higher rated pressure system and built-in circuit restrictions make them virtually self-cleaning, reduce maintenance to a minimum.
- New glass tube has a characterized internal taper which provides positive linear accuracy over the full extent of the calibrated scales.
- Easy-to-read Zero-centered scales permit use of instrument for normal inspection, statistical quality control, and as a tool setting gage.
- Interchangeability of component parts simplifies conversion from one amplification to another, reduces spare parts inventory costs.

Plus a complete line of air gage spindles, rings, snaps and cartridges all precision finished to give you greater accuracy, longer wear life. Free demonstration arranged upon request. Write for details today!

AIR GAGE DIVISION
DEARBORN GAGE COMPANY
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Circle 661 on Page 17

5,000 CASH REGISTER PARTS CLEANED IN 7½ MINUTES WITH

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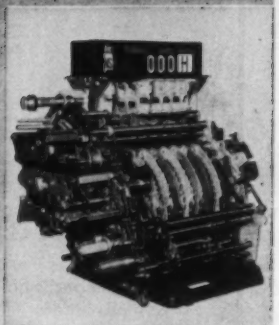

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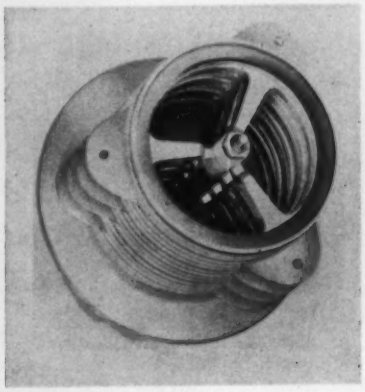
Detrex, a pioneer in the Metal Cleaning and Processing Field, is now the established leader! Offering the most complete combination of chemicals, equipment, and services in the industry, Detrex can properly recommend, engineer and service any cleaning application. Write for information today!

DETREX CHEMICAL INDUSTRIES, INC.

BOX 501, DETROIT 32, MICHIGAN

InterAct is a reaction eutectic. Under the influence of heat it eliminates the surface oxide layer and causes similar or dissimilar metals to flow together at temperatures lower than the melting point of either metal being used. It can be used to chemically join copper and aluminum and other materials such as magnesium, titanium, brass, zinc, silver, and gold.

The new material is available in wire coil, powder, or granular form for use in different types of joints. The resulting joint is usually stronger than either of the metals involved and is frequently more corrosion resistant.



SPECIAL relay is designed to operate under severe environmental conditions. Produced by Jennings Radio Mfg. Corp., the relay, housed in a stacked ceramic enclosure, contains contacts that operate in a vacuum. Relay will operate satisfactorily during vibration of 25G from 10 to 2000 cps, during 50G shock and at ambient temperatures to 200C without contact chatter. Illustration shows inside of relay. Each switching circuit employs three contacts in parallel to provide reliability at high current handling capacity. Continuous rating of the contacts is 25 amp at 300v dc.

Stable Ferroelectric Material Promising Memory Device

EXPLORATION in the field of ferroelectrics has resulted in the discovery of a new ferroelectric material by **B. T. Matthias** at Bell Telephone Laboratories. Known chemically as triglycine sulphate, the material has a rectangular voltage hysteresis loop and other desirable properties which make it suitable for switching circuits and memory devices.

Triglycine sulphate is stable chemically and does not decompose

Circle 662 on Page 17

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406	436	466	496	526	556	586	616	646	676	706	736	766	796
407	437	467	497	527	557	587	617	647	677	707	737	767	797
408	438	468	498	528	558	588	618	648	678	708	738	768	798
409	439	469	499	529	559	589	619	649	679	709	739	769	799
410	440	470	500	530	560	590	620	650	680	710	740	770	800
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412	442	472	502	532	562	592	622	652	682	712	742	772	802
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414	444	474	504	534	564	594	624	654	684	714	744	774	804
415	445	475	505	535	565	595	625	655	685	715	745	775	805
416	446	476	506	536	566	596	626	656	686	716	746	776	806
417	447	477	507	537	567	597	627	657	687	717	747	777	807
418	448	478	508	538	568	598	628	658	688	718	748	778	808
419	449	479	509	539	569	599	629	659	689	719	749	779	809
420	450	480	510	540	570	600	630	660	690	720	750	780	810
421	451	481	511	541	571	601	631	661	691	721	751	781	811
422	452	482	512	542	572	602	632	662	692	722	752	782	812
423	453	483	513	543	573	603	633	663	693	723	753	783	813
424	454	484	514	544	574	604	634	664	694	724	754	784	814
425	455	485	515	545	575	605	635	665	695	725	755	785	815
426	456	486	516	546	576	606	636	666	696	726	756	786	816
427	457	487	517	547	577	607	637	667	697	727	757	787	817
428	458	488	518	548	578	608	638	668	698	728	758	788	818
429	459	489	519	549	579	609	639	669	699	729	759	789	819
430	460	490	520	550	580	610	640	670	700	730	760	790	820

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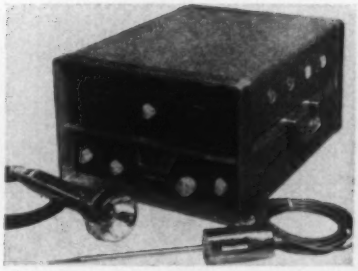
when exposed to moisture or to the atmosphere. It has adequate mechanical strength to permit handling in thin sheets. Large single crystals can be grown quite easily and a number of large-area slices can be cut from each crystal. Repeated switching when in a circuit does not cause any fatigue in triglycine sulphate. A given area will retain a given polarization indefinitely without any deterioration. Switching time, an important characteristic in any switching or memory device, depends on the characteristics of the material and the switching voltage. It appears that switching times of the order of one to two microseconds can easily be attained with this new material.

Electrodes can be applied to a slice cut from a single crystal by evaporating thin strips of metal on each side of the slice, the strips on one side being perpendicular to those on the other. Using this technique, thirty or more strips per inch can be applied, resulting in a memory or switching device capable of storing 900 or more bits of information on a square inch of crystal. A number of such slices can be assembled in a relatively small volume, resulting in a very compact assembly. Thickness of the slice can be from 5 to 10 mils, depending on the available pulsing voltage and the desired output. Switching can be accomplished with about 20 volts, a value easily obtained with transistorized circuitry.

New Paint Process Simplifies Dip Operations

EQUIPMENT for a new hot dip paint process has been introduced by David-Ludwig Co. The Harding hot dip process consists of preheating an article and then dipping it into paint heated to approximately 160F. The paint contains a chlorinated hydrocarbon solvent which quickly evaporates as the heated article is removed from the dip tank. This results in a quick drying, uniform thickness, and drip free coating of paint on the material.

David-Ludwig designs, fabricates and installs Harding process equipment. The new process affords savings in equipment and installation costs by the reduction of cooling areas, drip pans, fire prevention apparatus, and dump tanks normally associated with wet film dipping.

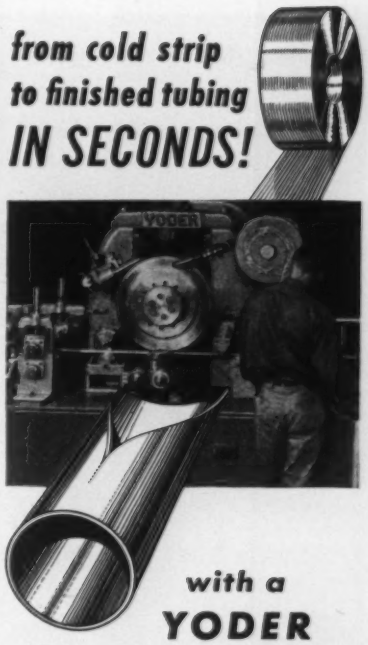


VIBRATION analyzer introduced by International Research & Development Corp. measures vibration amplitude from 0.1 to 100 mils, velocity from 0.03 to 30 ips, and frequency from 450 to 150,000 cpm. Unit incorporates a continuously variable filter to permit separate analysis of each frequency from 450 to 150,000 cpm. Other components furnished with the analyzer are a velocity type vibration pickup and a stroboscopic lamp to visually study rotating parts.

SPOTLIGHTING PEOPLE

David E. Laughlin appointed manager of Digimatic Marketing Section of Electronic Control Systems Inc. . . . **Russell R. Morgan** appointed executive vice president and director of Wheeler Associates Inc. . . . **Donald M. Miller** elected executive vice president of Airborne Instruments Laboratory . . . **J. E. Collins** elected board chairman of Valvair Corp. . . . **David G. Collins** named vice president of Speedway Mfg. Co., subsidiary of Thor Power Tool Co. . . . **Harold Chestnut** of General Electric Co. elected first president of newly formed International Federation of Automatic Control in Paris . . . **Roland L. Van Allen** appointed head of Circuit Research Section, Control, division of Magnetics Inc. . . . **Alvin J. Jones** appointed director of engineering of Motch & Merryweather Machinery Co. . . . **Russell S. Rockafellow** appointed manager of industrial engineering of Raytheon Mfg. Co. . . . **Alfred R. Zipf** named vice president in charge of Bank of America systems and equipment research activities . . . **P. H. Richey** named president and treasurer of Automatic Molding Machine Co., sub-

from cold strip to finished tubing IN SECONDS!



with a

YODER ELECTRIC-WELD TUBE MILL

One of the fastest . . . and one of the least expensive . . . methods of making steel tubing is with a Yoder Electric-Weld Tube Mill. The Yoder method eliminates the need for time-consuming heat treatments and costly conditioning furnaces for most tube needs. Scrap losses, too, are far lower than any other method . . . usually less than 2%.

The Yoder Type-M Mill shown above is operated by one man and a helper. Coiled strip on this mill is continuously cold-roll formed, welded and cut to required lengths in a matter of seconds . . . at speeds up to 340 f.p.m. The quality of the resulting tube is *constantly* better than the requirements of commercial standards. This is one of many reasons why manufacturers and users of tubing the world over are using more Yoder mills than all other makes combined.

If your business requires pipe and tubing, ferrous or non-ferrous, in sizes from ¼-inch up to 26-inch diameter, Yoder can supply the engineering service and machines to produce it faster and better for less! For complete details, write for the Yoder Tube Mill Manual. It's yours for the asking.

THE YODER COMPANY
5526 Walworth Ave. • Cleveland 2, Ohio

ENGINEERING YODER MANUFACTURING
PIPE AND TUBE MILLS
(ferrous or non-ferrous)

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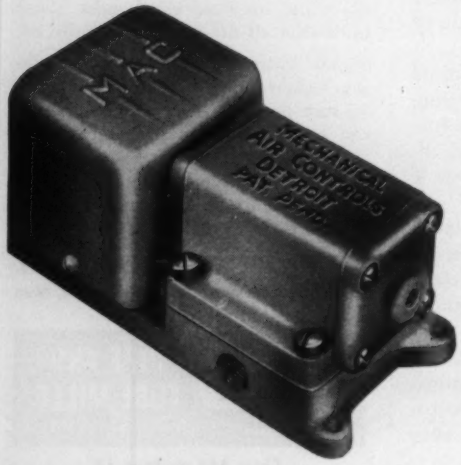
Masterpiece of simplicity



Consider the egg. Unique in shape, clean of line, its design is functionally perfect.

Much the same can be said of a MAC valve. Trim and compact, its simplified design meets the severe demands of our toughest customer. We engineered it to deliver the speed and stamina required by resistance-welding equipment . . . and knew this basic design would pay off handsomely in performance on less exacting jobs, too. That's why *all* MAC valves are built to these same rugged design specifications.

And that's why you can expect *more* from MAC—in efficiency and dependability, in longer life. Get proof. Contact a representative listed at right or send for the facts.

MECHANICAL AIR CONTROLS, INC.
10030 Capital, Oak Park, Detroit 37, Michigan

MAC

Circle 664 on Page 17

PHONE YOUR NEARBY "MAC" REPRESENTATIVE FOR DATA AND DELIVERY

ARKANSAS
Branch-Merwin Tool Specialists, 477 N. Bellevue, Memphis, Tenn., BRoadway 8-6102

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OAKLAND 8—The Rucker Co., 4700 San Pablo Ave., OLympic 3-5221
SOUTH GATE—The Rucker Co., 4956 Firestone Blvd., LOrain 4-2521

FLORIDA
MIAMI SPRINGS—Aero Hardware & Supply Co., 4301 Northwest 36th St., TUxedo 8-2414

ILLINOIS
CHICAGO 43—Mike C. Modrich Co., 10918 South Western Ave., HIlltop 5-3640

INDIANA
EVANSVILLE 14—Neff Engineering Co., 2509 Washington Ave., GReenleaf 7-4141
FORT WAYNE 3—Neff Engineering Co., P.O. Box 2001, Station A, 2339 Crescent Ave., EAstbrook 7391
INDIANAPOLIS 2—Neff Engineering Co., 1955 Central Ave., WAlnut 5-5311
SOUTH BEND 15—Neff Engineering Co., 707 South Eddy, ATlantic 7-5655

MASSACHUSETTS (and New England)
BOSTON 34—Electrical Apparatus Co., Inc., 1200 Soldiers Field Rd., STadium 2-7440

MICHIGAN
BAY CITY—Fred Kober, 506 S. Chilson St., TWinbrook 2-2629
FLINT 2—Kober Sales Engineering Co., 1115 Root St., CEdar 2-7165
WESTERN MICHIGAN—Everett Adams, 17212 Sharon Road, Chesaning, Michigan, VIctor 5-3446

MINNESOTA
MINNEAPOLIS 8—Air and Hydraulic Equipment Co., 15 E. 38th St., TAylor 3-6118

MISSISSIPPI
Branch-Merwin Tool Specialists, 477 N. Bellevue, Memphis, Tenn., BRoadway 8-6102

MISSOURI
ST. LOUIS COUNTY—Oscar E. Jost Co., P. O. Box 6, St. Ann, HArrison 8-4488

NEW YORK
BUFFALO 26—C. H. Tepas Co., 200 Washington Hwy., CIrcle 3210

OHIO
CINCINNATI—The R. W. Nichols Co., Fidelity Federal Savings Bldg., 2087-9 Sherman Ave., Norwood, ELmhurst 1-2440
DAYTON—The R. W. Nichols Co., 407 Realty Bldg., MIchigan 4724
OLMSTED FALLS—The R. W. Nichols Co., P. O. Box 6, ADams 5-3366
TOLEDO 4—The R. W. Nichols Co., 510 Manhattan Building, CHerry 1-1447

OREGON
PORTLAND—The Rucker Co., 911 N. W. Hoyt St., CApitol 3-0205

PENNSYLVANIA
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MEMPHIS—Branch-Merwin Tool Specialists, 477 N. Bellevue, BRoadway 8-6102

TEXAS
DALLAS 35—Womack Machine Supply Co., 2010 Shea Rd., FLeetwood 7-3871

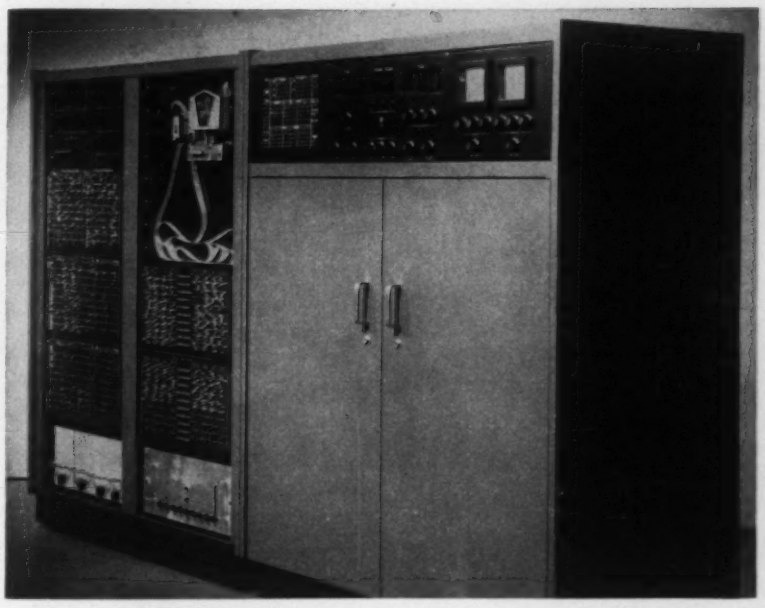
WASHINGTON
SEATTLE—The Rucker Co., 1000 4th Ave., South, MAin 2783

WISCONSIN
MILWAUKEE 17—Neff Engineering Co., 5856 N. Pt. Washington Rd., EDgewood 2-1579

CANADA
MONTREAL—L. S. Tarshis & Sons, Ltd., 450 McGill St., Quebec, PLateau 2963
TORONTO—Trevor Babbs, National Time & Signal Co., 72 Shilton Rd., Agincourt, Ontario, OXford 1-4857

MECHANICAL AIR CONTROLS, INC.
DETROIT 37, MICHIGAN
MAC

Circle 664 on Page 17

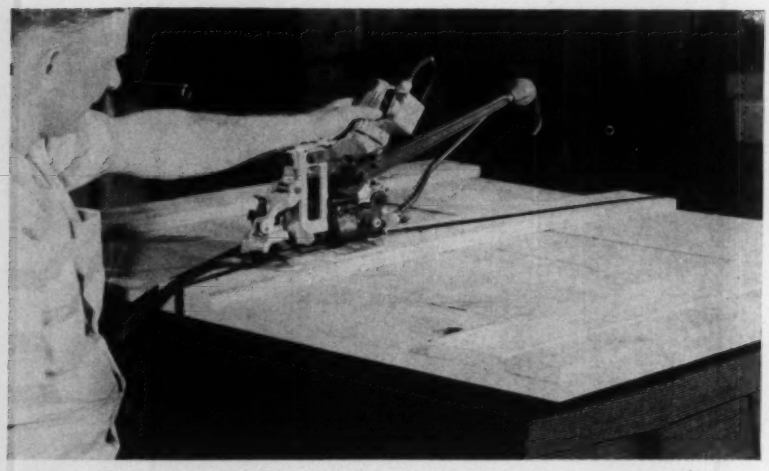


DATA processing system developed by Beckman Instruments Inc., for continuous round-the-clock monitoring and control of a petroleum refinery re-former. System achieves operating reliability through use of all-transistor circuitry and magnetic amplifiers grouped in standard modules, and unit will monitor inputs from thermocouples, pressure transducers and flow meters. Built-in computer mechanisms compensate flows for pressure and a digital totalizer provides hourly and daily totals of material inputs. Designed for rapid scanning, computation, and identification of off normal process variables, the system will make possible optimum plant control and provide precise operating data for accounting purposes.

sidiary of Wagner Bros. Inc. . . . **Chester A. Grondzik** appointed manager of Systems Automation Group, H. W. Butterworth & Sons Co . . . **John von Rosen** named director of manufacturing engineering for Chrysler Corp. . . . **Dr. C. D. W. Thornton** appointed director of research and development for Farnsworth Electronics Co. . . . **John E. Rowe** named executive vice president of Tomkins-Johnson Co. . . . **Robert W. Olson** appointed vice president of research and engineering of Texas Instruments Inc. . . . **Perry L. Toback** named head of application engineering for Hoffman Semiconductor Div. of Hoffman Electronics Corp. . . . **Charles Proctor** appointed chief production engineer of Topp Mfg. Co., a division of Topp Industries Inc.

SPOTLIGHTING PRODUCTS

Bellows-type flow meter accurate to within ½ of 1% and designed primarily for oil and chemical industries has been developed by Minneapolis - Honeywell Regulator Co. . . . *Relays* containing built-in indicator neon lamps for spotting circuit malfunctions are available from Line Electric Co., Newark, N. J. . . . *High-nickel alloy strip* in thicknesses as small as 0.0005 inch is offered by American Silver Co. for use in miniaturized products . . . *"Atomic lamps"* which provide power-free, uninterrupted illumination up to 10 years have been developed by United States Radium Corp. . . . *Folding machine* designed to produce accordion folds in strip or roll instrument charts has been offered by Benson-Lehner Corp. . . . *Buffing compound*, used for scratch-free finishing of plastics, contains an ingredient that imparts anti-static properties to part being finished and is marketed by Hanson-Van Winkle-Munning Co. . . . *Multiple drill head* attachment and an automatic index table designed to eliminate close center drilling problems have been introduced by Con-Ray Corp., Dayton, Ohio . . . *Battery temperature control*, used to keep electrolytic solution in storage batteries from overheating during charging, has been devel-

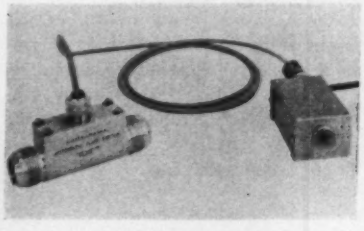


ELECTRIC powered strapping tool has been developed by Signode Steel Strapping Co. The new model uses a small 115v motor to provide high tension packages without worker fatigue. A single stroke hand lever seals and cuts the strap. The portable power strapping tool weighs only 2 lb with 75 seals in its magazine. Unit is used with 5/8 or 3/4 inch straps, and tension is adjustable up to 1600 lbs.

oped by Vapor Heating Corp., Chicago . . . *Counter and totalizer,* to enable processors to maintain an accurate inventory control on ingredients being fed into a proportioning system, has been announced by Richardson Scale Co. . . . *New iron-chromium-aluminum alloy* for use on moderately high temperature resistance heating applications such as small appliances and on industrial heating devices where continuous operating temperatures do not exceed 2150F has been announced by Hoskins Mfg. Co.

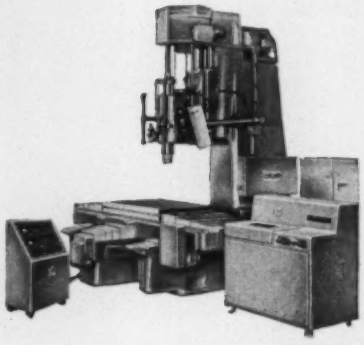
SPOTLIGHTING PLANTS

Production Machinery Corp. moved its engineering and sales offices to larger quarters in Mentor, Ohio . . . **E. W. Bliss Co.** moved its can machinery manufacturing operation to larger quarters in Hastings, Mich. . . . **United States Drill Head Co.** opened its new Standard Foundry Div. plant in Cincinnati . . . **Barden Corp.** has begun construction of a ball bearing plant in Danbury, Conn. . . . **Ferguson Machine Corp. of Ind.** announced move to larger quarters in Maplewood, Mo. . . . **American Measurement & Control Inc.** has been formed to conduct research and development and to produce electronic, mechanical and electrohydraulic products in Waltham, Mass. . . . **KDI Corp.,** Rochester, N. Y., acquired the precision products division of Gruen Industries . . . **Automatic Electric Co.** opened its new 1,520,000 sq ft plant in Northlake, Ill. . . . **Taber Instrument Corp.** opened its new Electronics Div. in North Tonawanda, N. Y. . . . **United States Plywood Corp.** opened its new automated plant for pre-finishing plywood panels in Orangeburg, S. C. . . . **Monroe Calculating Machine Co.** announced impending merger with Litton Industries . . . **Electronic Specialty Co.** announced the purchase of Cado Div. of Electromation Inc. . . . **A. J. Gerrard & Co.** named as exclusive sales and service representative for Guide automatic bundling and wrapping



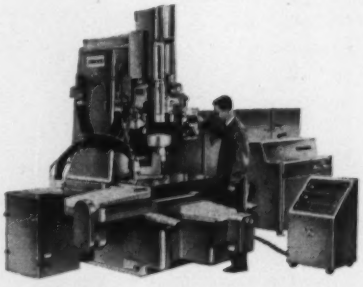
FLOW switch for either liquid or gas has been developed by Potter Aeronautical Corp. Unit is designed with in-line flow characteristics and will activate a switch for indication or control in flow systems. Pottermeter flow switch will also detect reverse flow and is available in aluminum, stainless steel, bronze, nickel, Monel, Inconel and other metals.

PRATT & WHITNEY
NUMERICAL CONTROL
APPLICATIONS



ELECTROLIMIT JIG BORER

Equipped with Numerical Control, the P&W No. 2E Jig Borer is equally suitable for toolroom and precision production applications. Settings accurate to .0001" are made automatically from data supplied by a punched tape or an operator's keyboard.



VERTICAL PRECISION HOLE GRINDER

Table and carriage are similar in design to the No. 2E Jig Borer and the same ultra-precision Electrolimit Measuring System is employed. Column, however, is equipped with interchangeable, turbine-driven grinding heads for spindle speeds to 100,000 rpm.

PRECISION ROTARY TABLES

These Pratt & Whitney Rotary Tables are the ultimate in precision and convenience for circular spacing, graduating and angular positioning. Settings accurate to 5 seconds of arc (2 seconds for repetitive settings) are made automatically from data supplied by punched tape or operator's keyboard.

PRATT & WHITNEY

Circle 665 on Page 17

TO "TENTHS" IN SECONDS

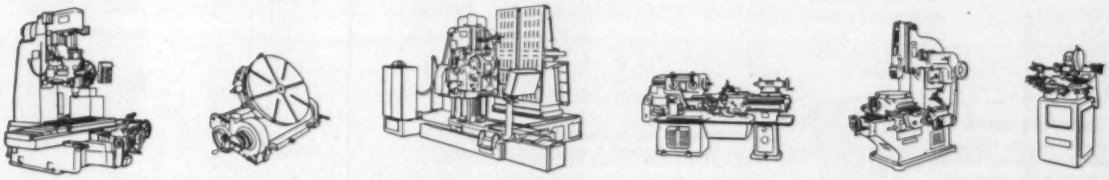
. . . *and no mistakes!*

WITH NEW PRATT & WHITNEY NUMERICAL CONTROL

Operating under Numerical Control, this P&W Precision Hole Grinder is positioned and re-positioned — accurate to .0001" — in an average of only 14 seconds! And since settings are controlled by a punched tape, the chance of work spoilage through operator error in reading blueprint data or setting dials is eliminated. The operator is free to concentrate his attention on work quality.

Applied to Pratt & Whitney Jig Borers, Precision Hole Grinders, Rotary Tables and special machines, Numerical Control not only speeds up toolroom operations, but also makes the high precision of these machines available for efficient short- or long-run production work. In this type work, time savings up to 40% over manual operation are realized. Compare the performance of your present manually-controlled machines with the new standards of speed, accuracy and economy being established by numerically-controlled P&W equipment. If they don't measure up, you are missing important opportunities for improved work quality, larger savings and greater profits.

Write now for complete information.
Pratt & Whitney Company, Incorporated,
35 Charter Oak Boulevard, West Hartford, Conn.



JIG BORERS . . . ROTARY TABLES . . . KELLER MACHINES . . . LATHES . . . VERTICAL SHAPERS . . . CUTTER AND RADIUS GRINDERS

PRATT & WHITNEY

FIRST CHOICE FOR ACCURACY

MACHINE TOOLS • GAGES • CUTTING TOOLS

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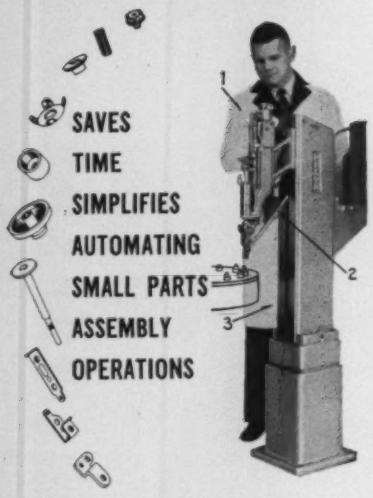
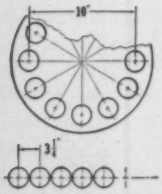
New Standard DIXON Auto-Positioner



AUTOMATICALLY GUIDES PARTS OF 1/16" TO 3" O.D. SIZE AT RATES UP TO 6,000 PER HOUR

The new Dixon Auto-Positioner combines three standardized units—(1) Automatic Air-Operated Positioner, (2) Automatic Escapement, (3) Mounting Structure. Because the unit is compact and fits into small space, it provides an economical solution for a wide range of small parts assembly. It has an exclusive sensing feature that automatically stops your machines when parts are missing or malformed. Auto-Positioners are easily arranged at single or multiple stations with feeders, feed tracks, transfer or indexing tables. With properly tooled chucks, positioning punch, and proven feeder, parts are positioned at rates up to 6,000 pieces per hour. Individual units or any combination of standard components available from stock. Tooled Auto-Positioners provided to suit needs.



May be located at adjacent stations, only 3¼" apart for straight-line indexing, or on 12-station dial with a 5" fixture radius.

WRITE FOR FREE DATA SHEETS
New bulletins supply specifications and application data on standardized units now available from stock.

DIXON AUTOMATIC TOOL, Inc.
2312–23 rd AVENUE
ROCKFORD, ILLINOIS
Equipment for Automatic Parts Handling and Assembly

Circle 666 on Page 17

equipment by Guide Co. . . . **Dresser Industries Inc.** acquired Gardner-Denver Co. subject to approval by stockholders . . . **Taylor-Winfield Corp.** purchased the exclusive lines of metal-working and work-handling machinery formerly built by Struthers-Wells Corp.

MEETINGS AND EVENTS

Dec. 2-6—

Twenty - sixth Exposition of Chemical Industries. To be held New York Coliseum. Additional information may be obtained from exposition manager, E. K. Stevens, 480 Lexington Ave., New York 17, N. Y.

Dec. 9-13—

Eastern Joint Computer Conference & Exhibit. Co-sponsored by IRE, AIEE, and Association for Computing Machinery to be held Sheraton-Park Hotel, Washington, D. C. Additional information may be obtained from M. B. Catline, Council for Economic and Industry Research Inc., Arlington 2, Va.

Dec. 18-19—

Radio - Electronics - Television Manufacturers Association. Conference on maintainability of electronic equipment to be held University of Southern California, Los Angeles. Additional information may be obtained from association headquarters, 11 West 42nd St., New York 36, N. Y.

Jan. 6-8—

Fourth National Symposium on Reliability and Quality Control. Jointly sponsored by IRE, ASQC, AIEE and RETMA and to be held at Hotel Statler, Washington, D. C. Additional information may be obtained from Richard M. Jacobs, Radio Corp. of America, Box 33, Moorestown, N. J.

Jan. 13-17—

Society of Automotive Engineers Inc. Annual Meeting and Engineering Display to be held at the Sheraton-Cadillac and Statler Hotels, Detroit. Additional information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Jan. 14-15—

Instrument Society of America. Yankee Instrument Fair & Symposium to be held at Hotel Bradford, Boston. Additional information may be obtained from ISA, Boston Section Inc., Box 282, Boston 1, Mass.

Jan. 27-30—

Plant Maintenance & Engineering Show. To be held at the International Amphitheatre, Chicago. Additional information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 28-31—

Institute of Aeronautical Sciences. 25th Annual Meeting to be held at the Sheraton-Astor Hotel, New York. Additional information is available from IAS headquarters, 2 East 64th St., New York 21, N. Y.

Feb. 2-7—

American Institute of Electrical Engineers. Winter General Meeting to be held at the Hotel Statler, New York. Additional information can be obtained from institute headquarters, 33 W. 39th St., New York 18, N. Y.

Feb. 4-6—

Society of the Plastics Industry Inc. 13th Annual Technical and Management Conference of the Reinforced Plastics Div. to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from SPI headquarters, 250 Park Ave., New York 17, N. Y.

"It was dreamed up by a designer who used to work for me."

The *FORWARD* Look develops...

AUTOMATIC CAR-A-MINUTE ASSEMBLY WITH WESTINGHOUSE DRIVES AND CONTROL

This man helps direct a 1960-new control system engineered by Chrysler Corporation and Westinghouse for unique material-handling methods. Utilizing more electrical power and exacting control, Westinghouse designed this system to automatically synchronize the flow and positioning of parts for assembly along 51 conveyor lines. Here is a system, too, that minimizes unscheduled plant down time and many maintenance headaches.

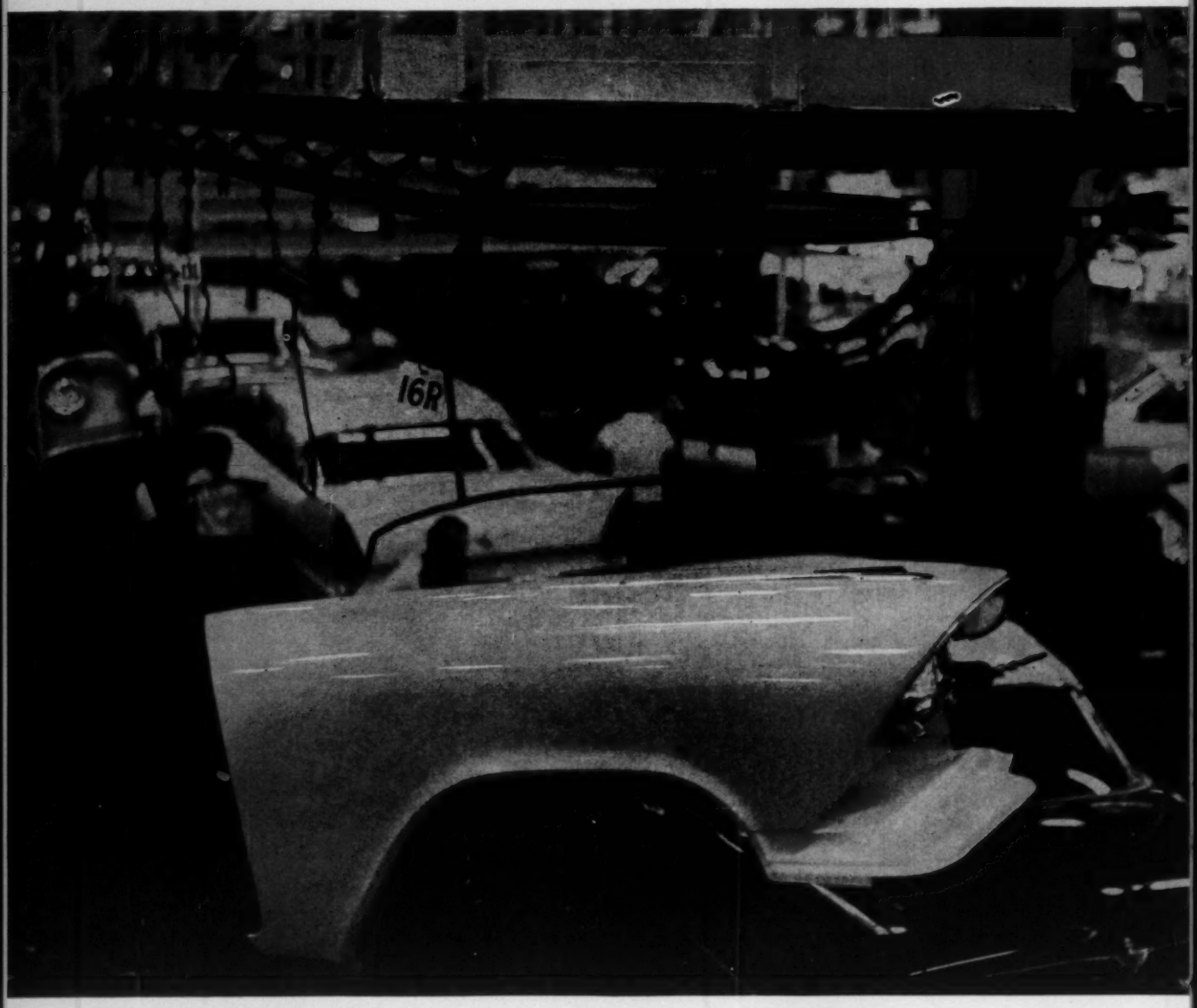
On the next five pages you'll see how Chrysler is perfecting "tomorrow's" assembly . . . today. Here are head-start ideas you can use, if you begin now to POWER-UP electrically.

MP-3058

YOU CAN BE SURE...IF IT'S Westinghouse

Circle 667 on Page 17

How do ivory fenders reach the ivory body shell on time and in position?



MAGAMP-CONTROLLED AV DRIVES INSURE EXACT MATCH-UP OF BODY PARTS

In this Plymouth assembly plant, two and one-half miles of floor conveyor and over five miles of monorail conveyor are synchronized to travel in unison. Transfer from one conveyor to another is completely automatic at hundreds of transfer points. For example, front fenders (above) travel to the right and left side of the body assembly conveyor, arriving at the assembly point exactly in step with a body shell of the same color.

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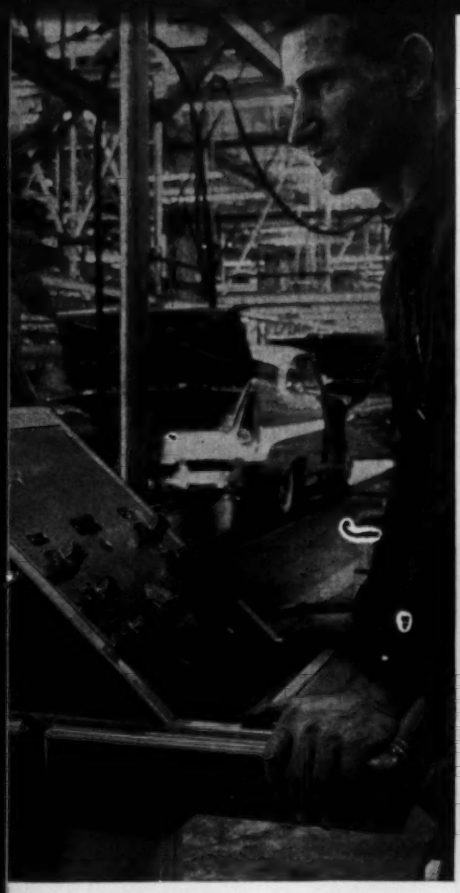
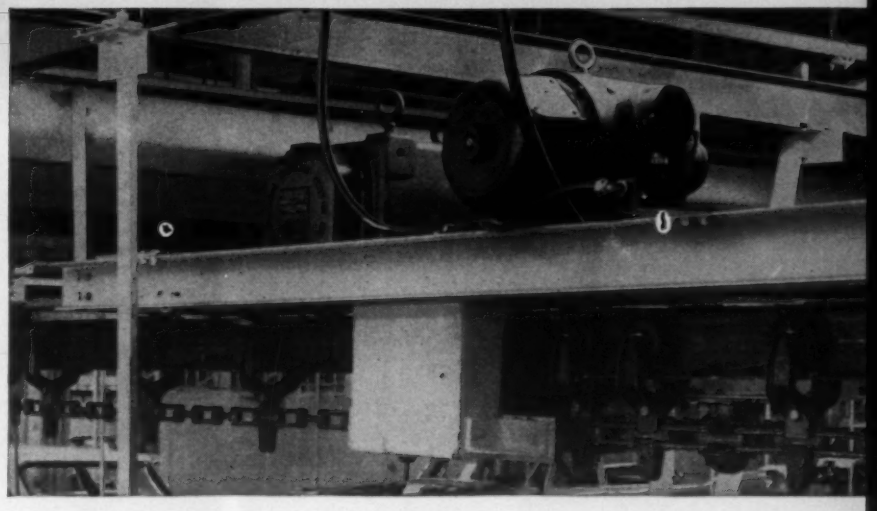


▲ *Fully automatic, Magamp speed and position control can be operated manually if desired. Magamp is most ideally suited to automatic operation as it is a highly reliable static device requiring no maintenance and no warm-up time.*

▼ *Conveyor AV Drive components are factory-assembled in free-standing cabinets centrally located in each plant zone.*



Westinghouse Life-Line® Motors ▶ *are located on conveyor supports or below the floor for conveyor drives. Prelubricated bearings and rugged insulation protection require minimum maintenance.*

Westinghouse AV Drives provide the complete, adjustable voltage d-c drive and regulator system to power up and synchronize all conveyors. A synchro-tie transmitter on the lead conveyor, or an independently driven transmitter, is used as a master reference for all slave conveyor sections. The transmitter on each slave conveyor is used to signal exact conveyor position. A Magamp* regulator compares the master and slave synchro-tie signal and makes any necessary correction to hold each slave conveyor in step with the master.

Exact control of the line speed is possible by means of incremental speed adjustment of the master synchro-tie transmitter. On multi-motor conveyor section drives, correct load sharing between motors is insured by proper machine and control coordination.

*Trade-Mark

Next page—Static control memory helps schedule assembly.

YOU CAN BE SURE...IF IT'S Westinghouse

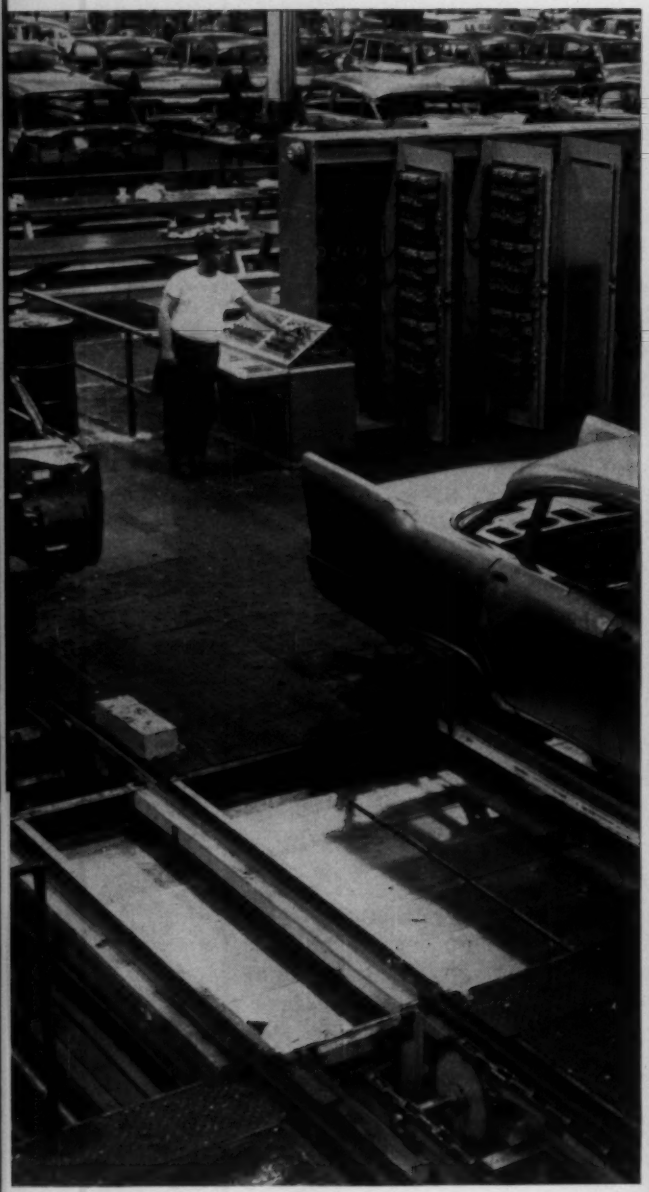
Circle 667 on Page 17

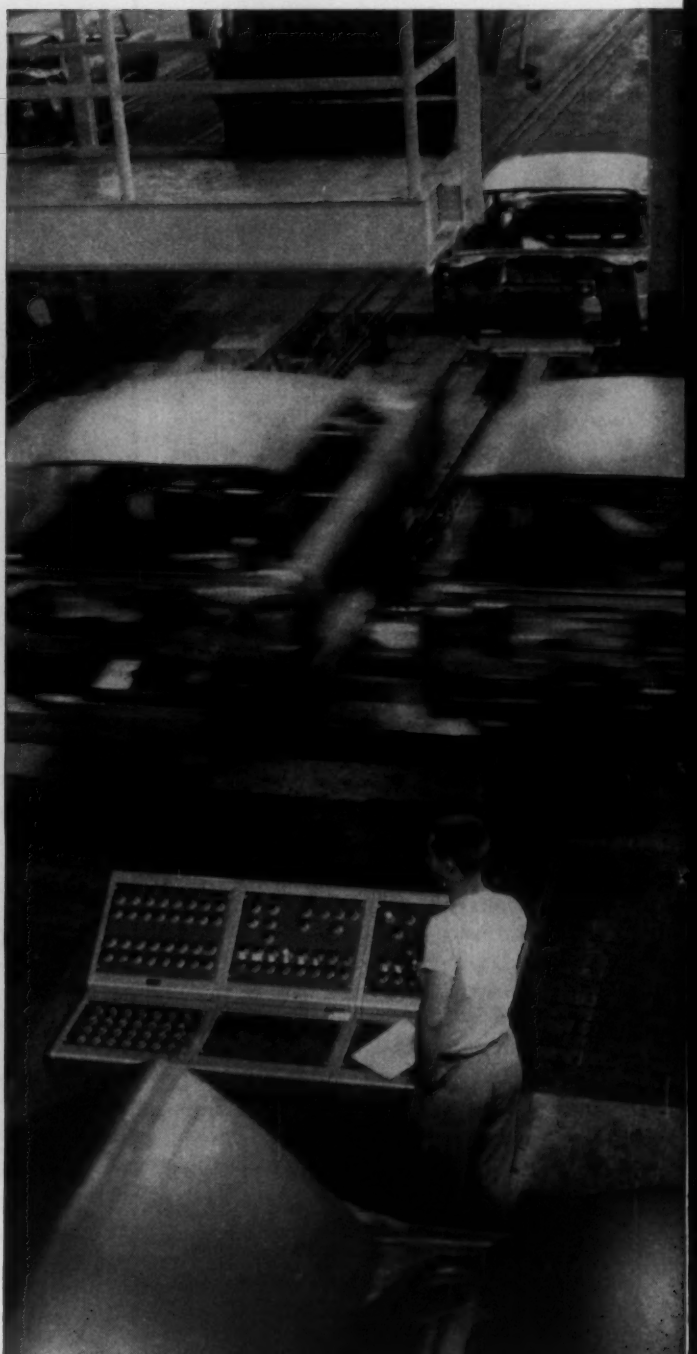
How is each body shell picked out of hundreds and prescheduled for color styling?

CYPAK CONTROLS
PUSHBUTTON SORTING, STORING AND TRANSFERRING

Modern assembly means no manual handling at the Plymouth plant in Newark, Delaware. Example—Cypak* control systems provide pushbutton handling for each body shell as it is stored and transferred through this 15-conveyor-line

*Trade-Mark





Circle 667 on Page 17

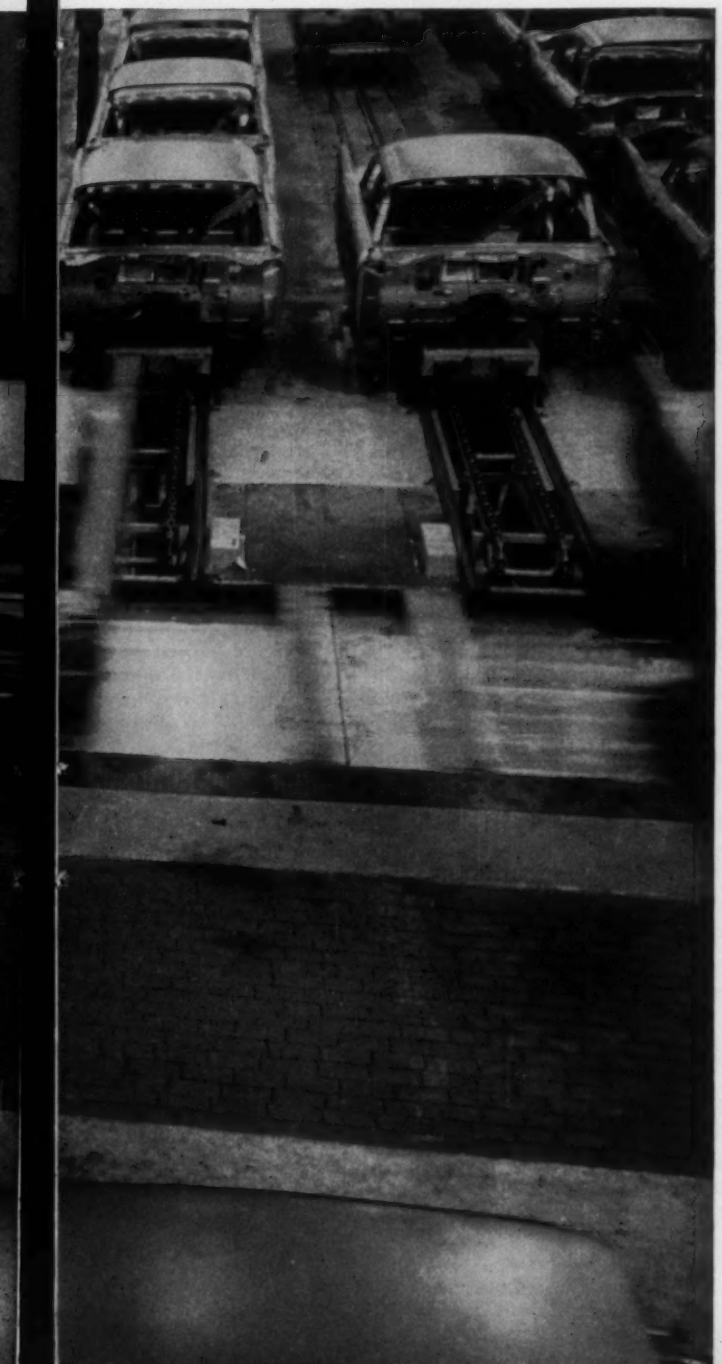
storage bank. Cypak takes full responsibility for storage and for removing each auto body in preselected order to meet paint shop scheduling.

The operator at the console (below left) selects a storage line for each auto body by pressing a pushbutton. This initiates an indexing cycle which automatically follows through at all transfer points. At the other end of the storage line (below center) an operator selects the proper production mix of body style. Cypak automatically indexes the body shells through each transfer point to the main conveyor.

Cypak static control was selected for this memory storage system because it is completely maintenance-free. System reliability is extremely high.

Next page—Control planning simplifies trouble shooting.

YOU CAN BE SURE...IF IT'S Westinghouse

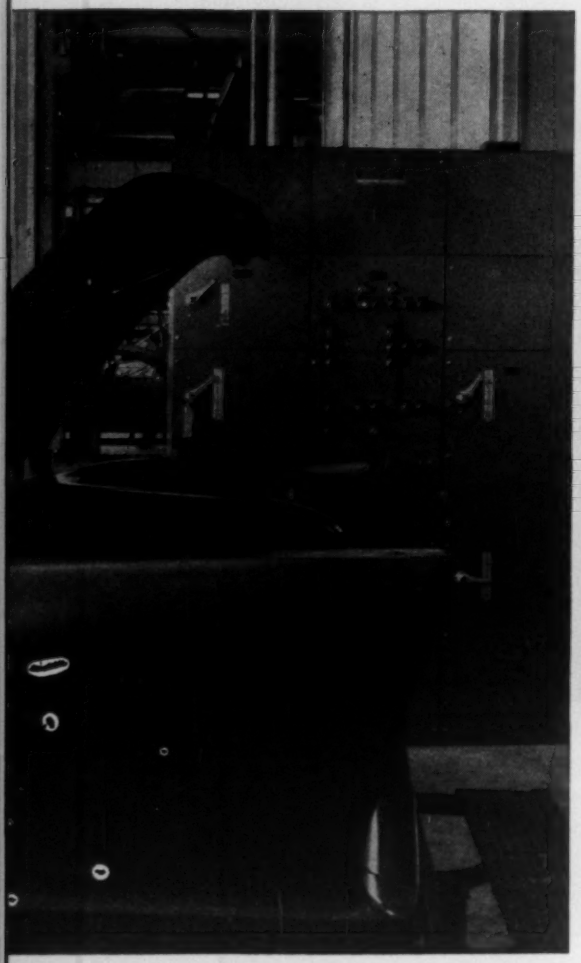


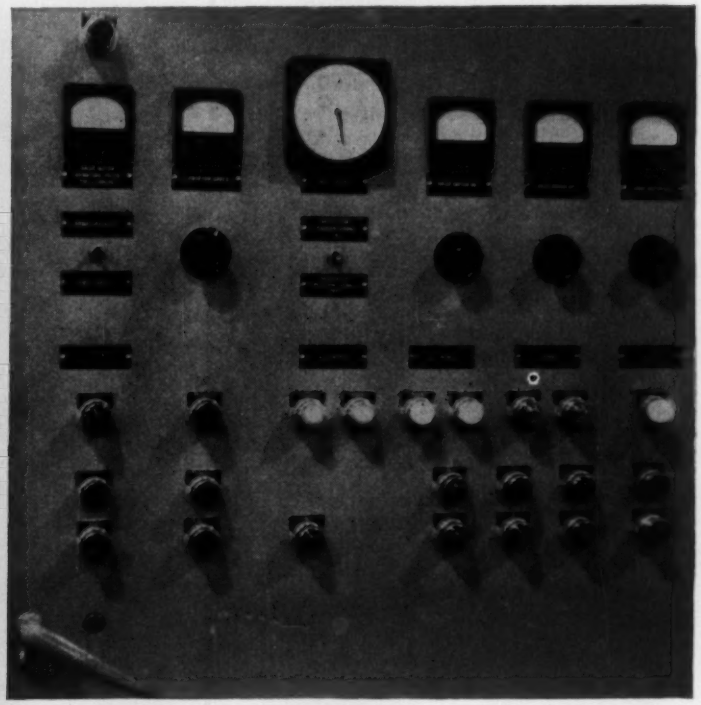
Cypak control elements are plugged into power channel busway to form compact system assembly for easy inspection. Wiring system diagram designates proper connections for tab connectors between top terminals.

Circle 667 on Page 17

How does electrical planning limit down time?

COORDINATED CONTROL AUTOMATICALLY TAKES RESPONSIBILITY





. . . to simplify trouble shooting

Unscheduled down time is minimized because of careful planning between Chrysler and Westinghouse engineers. Trouble locations are pinpointed by signals on panel-front diagrams (above left) of conveyor lines. A panel-front synchroscope (above right) is located on each AV Drive cabinet to keep electricians accurately informed of conveyor synchronization.

Checks on the position-regulating system are made automatically. If a position error above tolerance occurs, the conveyor will stop and postpone transfer until it is safe.

. . . during shutdown and start-up

Cascade-type electrical interlocking prevents pile-ups wherever a series of conveyors are running together. Any stop on one conveyor will stop all conveyors feeding into it. After the first conveyor is restarted, the others will automatically restart. The responsibility for starting and stopping conveyors is built in through advanced electrical planning.

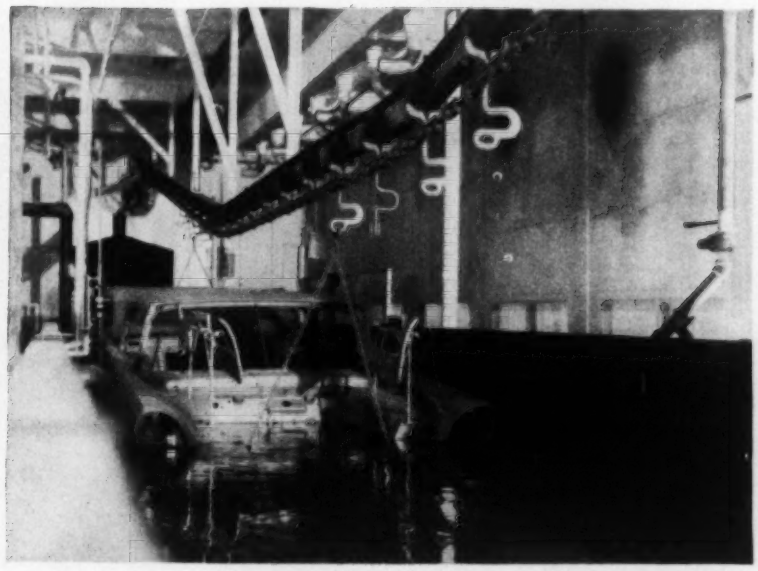
If your production plans call for forward-looking material-handling drives and control, call your local Westinghouse sales engineer for expert counsel and experience, or write Westinghouse Electric Corporation, 3 Gateway Center, Box 868, Pittsburgh 30, Pennsylvania.

YOU CAN BE SURE...IF IT'S

Westinghouse

Circle 667 on Page 17

By JAMES C. KEEBLER
Managing Editor



Prime coat of paint is applied to interior of structural portion of unitized underbodies of 1958 Lincolns in this 70 by 9 foot dip tank that contains 10,000 gallons of paint at a depth of four feet. Conveyor submerges bodies to a depth of 28 inches. Paint is filtered and its temperature maintained to insure constant viscosity and control flow.

Unitized and Dipped

BUILDING a luxurious product for a prestige market is a tricky business. The design must have the right combination of snob appeal and good taste. The price tag must be high to underscore the selectivity of the buyers. The quality must be first-rate so that the big bank roll customer doesn't feel that he's been rolled. The whole combination of product, style, workmanship, performance, advertising, and salesmanship must create a climate of excellence.

Classic Elegance

Each of the Big Three has a contender in the field, and although none may be striving to outsell Chevy (Too Commonplace! is a valid criticism of a prestige auto) they do compete comparatively for their share of the elegant carriage trade. If volume of sales is your criterion of success in this game, then you'll name Cadillac the winner. If progress is most important to you, Chrysler's Imperial (sold more than 3 times as many '57s as they did '56s) is a real blue ribbon entry.

However, the only competitor in this contest to offer an "entirely new concept in uncommon luxury" for 1958 is Ford's Lincoln Div. Their brand spanking new plant in Wixom, Mich. is devoted entirely to the assembly of the Lincoln Premiere, Capri, and Continental Mark III series. The place has a competitive atmosphere and there seems to be no secret about the idea that they'd like to outsell Cadillac.

Since such a venture could not be undertaken on a shoestring, it is not surprising that the Ford Motor Co. has underwritten the project to the tune of a completely new auto design to be made in this new assembly plant.

Unitized Construction

One of the things that makes the car different is unitized construction. This means the frame is built as an integral part of the body, and the front fenders are welded to the body as part of the body build-up. Lincoln is pioneering this type of construction for Ford Motor Co.

Subassembly weldments; including structural members, rear compartment pan, front engine compartment, and engine supports; are received from other plants and assembled here on merry-go-round welding fixtures to form the underbody assembly. Another merry-go-round setup is used to build-up the side assembly weldments.

One underbody assembly and two side assemblies are joined to a roof and two front fenders in a single-stage framing buck that holds each component in proper alignment for welding. Additional spot welding is required by unitized design. Lincoln's '57 model specified 2205 spotwelds, whereas the '58 gets 3300 spotwelds in this plant.

After the body is removed from the framing buck, it is placed on a skid and progresses through conventional respot, arc and gas weld, solder, and door hanging operations.

Unitized construction with welded-on front fenders enables all body panels except the hood to be painted simultaneously with the body paint equipment. This adds to the overall quality of the paint job.

Prior to spray painting, however, the unitized underbody, including all its box members, must be painted inside to prevent rust-

ing. This provides an interesting study in automation.

Upstairs Operations

All painting operations in this plant are located on the second floor. Isolation of paint operations from the rest of the plant is to allow for better control of ventilating conditions in the paint department and to prevent contamination by dirt produced in metal finishing, trim manufacture and other operations, which are difficult to segregate when the paint equipment and the assembly operations are intermingled in the conventional one-floor plant.

It is felt that this plan will allow much simpler rearrangements on the first floor as required for model changes from year to year.

The equipment in the paint shop is arranged so that the heat processing ovens are segregated from those operations requiring operators in the area. Isolation of heat processing equipment produces better working conditions.

The paint system is the recirculating type which means that all paint is agitated in a central paint room and pumped throughout the plant for operational usage. The system runs continuously 24 hours a day, seven days a week.

Directly from an elevator which raises the unit from the construction department, the bodies are changed from the skids to an overhead hanging conveyor for movement through the paint processes.

The skids are removed automatically and loaded on a trailer train to be transported and reinstalled to the unit later in the paint department. A gas-off operator gives the unit a manual washing to remove all heavy grease. Next, the unit moves through a six-stage phosphate system. Between the phosphate and drying oven is a drain and blow-off operation to remove trapped water from difficult areas. The unit then proceeds through a phosphate dry-off oven and into a cooling tunnel prior to prime painting in a dip tank.

Dipped

In order to give the unitized underbody sufficient rust protection the entire unit is submerged to a depth of 28 inches above the rocker panel. Painting begins by this process from the inside out.

The temperature of the body going into the tank is room temperature, around 72-75 degrees.

The body travels through a paint bath containing 10,000 gallons in a tank measuring 70 feet long by nine feet wide. The paint is filtered 100 per cent and maintained at a temperature of 75 degrees to insure constant viscosity. The viscosity is recorded to measure the flow of paint.

As the body drains and dries it is shifted through several positions to permit excess paint to drip away. Next, it travels into a spray booth for two wet coats of red primer. Two wet coats of gray surface paint are then applied and the four coats are baked in an oven at 375 degrees.

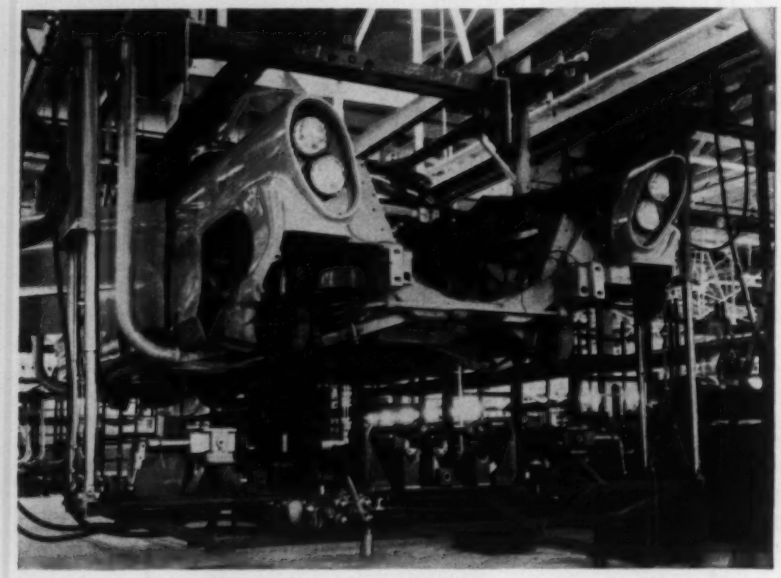
Although automation of such things as the control of liquid level, temperature, pressure, and viscosity are commonly thought of as more pertinent to chemical processing than auto assembly, it can be seen that they play a large role in the successful manufacture of unitized bodies.

Suspended Assembly

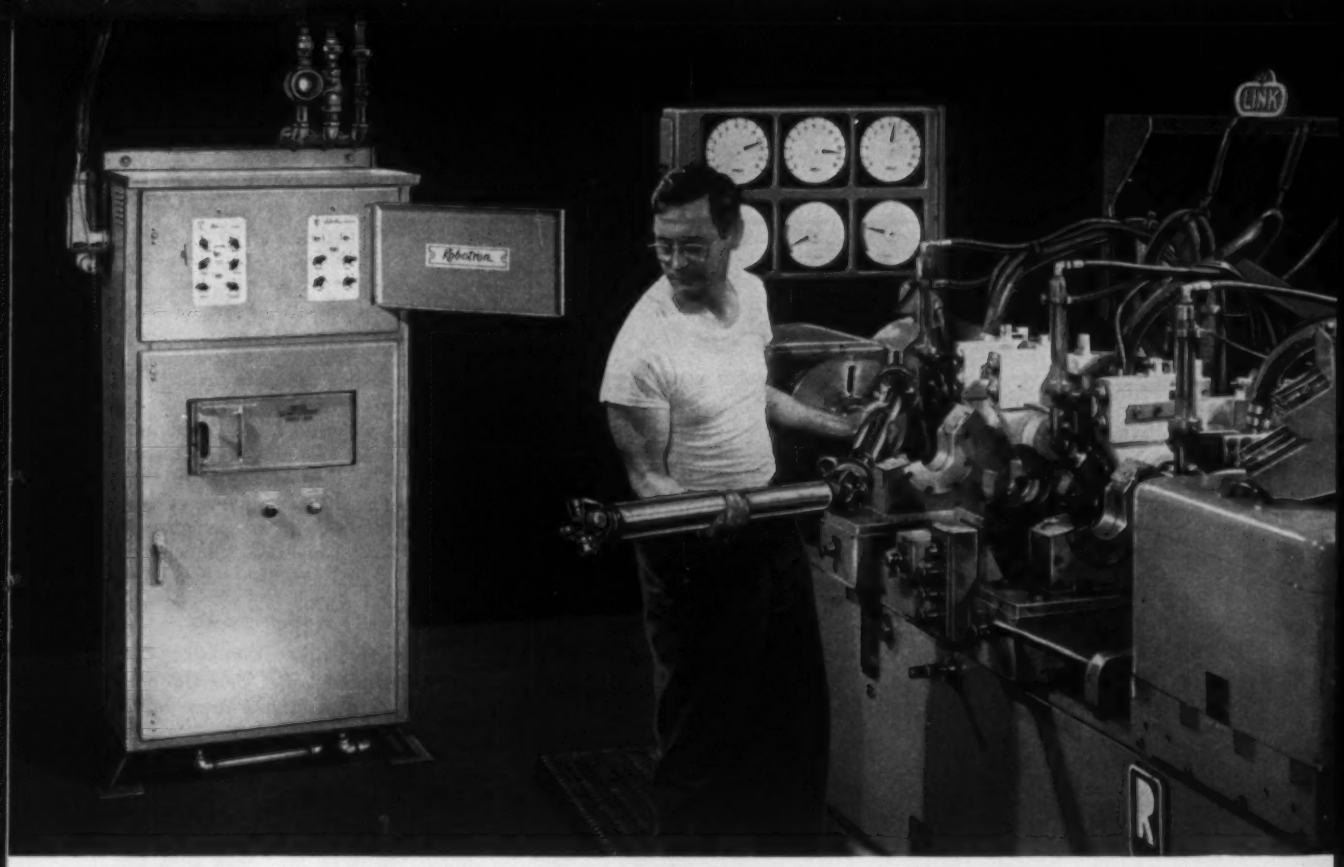
Unitized bodies have brought changes to the final assembly line too. Bodies are introduced at the start of the line on special fixtures suspended from an overhead conveyor. Exhaust system, fuel and brake lines, front suspension, rear axle and drive shaft are all assembled up from underneath. The engine is dropped in from above.

After the wheels are assembled, the overhead conveyor lowers the units to the final line flat top conveyor, the fixtures disengage automatically, and from here on operations are similar to those seen in other assembly plants.

"Unitized and Dipped" may or may not prove to be the industry's trend, but two things are certain: 1. The switchover is more clean cut when accomplished in a new plant than in attempting conversion of existing facilities. 2. The manufacturing engineers who set up such new facilities are ever on the lookout for ways to do their operations more automatically.



Unitized body of 1958 Lincoln is shown suspended from overhead conveyor of final assembly line. Fixture at this station is used to set caster and camber of front wheel spindles.



Torque shaft assembly welded for balance and demagnetized in one operation

Robotron resistance welding controls solve costly production problem for automotive parts manufacturer

A prominent manufacturer of power steering equipment faced a costly problem involving dynamic balance in torque shaft assemblies. The company uses a specially designed machine to rotate the shaft at high speed, enabling transducers to measure the amount and location of out-of-balance and register this information on calibrated recording meters. The machine is then stopped and selected balancing weights are projection welded at indicated points along the shaft. This procedure is repeated until perfect dynamic balance is obtained. The entire operation is accomplished without removing the shaft assembly from the machine and costly handling time is eliminated.

However, in welding the balancing weights, a serious problem arose. Though fast and efficient, the resistance welding operation, with conventional controls, left an objectionable amount of residual magnetism in the shaft. This condition attracted metal filings to bearing surfaces, causing excessive wear and vibration.

The problem: how to balance the shaft and eliminate objectionable magnetism in one complete operation.

Using an imaginative new approach to the problem, Robotron engineers developed resistance welding controls employing a new technique in the application of up-down slope control. Result: *balancing weights welded and shaft demagnetized in one operation.*

Solving tough production problems by introducing new concepts in resistance welding controls is our business. Tell us *your* problem. A letter or phone call will receive prompt attention.

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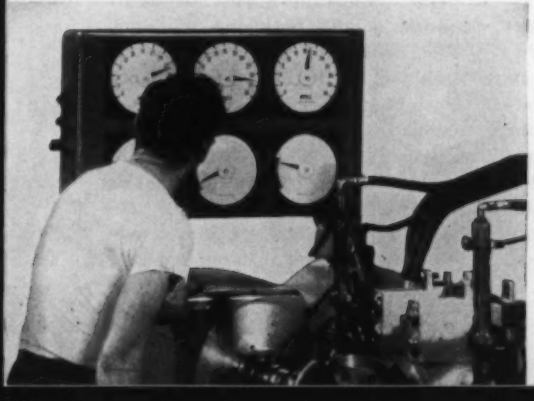

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Circle 668 on Page 17

notes from britain

By FRANK WOOLLARD
British Correspondent

Automatic loading hoppers supplied by Hymatic Engineering Co. increase efficiency of scrap baling presses. Arrangement permits load of scrap to be collected while press is compressing another load.

In Search of Fundamentals

AS A PHILOSOPHY of manufacture, automation continues to gain ground in Britain and the latest manifestation of this is the emergence of a new organisation bearing the name "The British Conference On Automation and Computation". This, however, is not a new Institution or Society, although it may conceivably become one in due course. It can, perhaps, be best described as a coterie comprising all the professional bodies who are interested in automation and who will, through this organisation, be enabled to hold conferences which will contribute to the existing knowledge of automation.

The moving spirit in this matter is the Institution of Mechanical Engineers who have invited other interested institutions to join with them in making a study of the new technology. It is proposed that the Conference will consider three main issues. There will be a group to investigate the engineering applications of automation; the development and application of computers, programming techniques, and automatic controls; and the economic and sociological implications of the continuing growth of automation in industry and in business.

Initial Event

The Mechanical Engineers are to sponsor a conference on the "Technology of Engineering Manufacture" in London during March of next year. A small planning panel has been set up under the chairmanship of Dr. Galloway—Member of Council—to make the detailed arrangements. Six sessions will be held under such general headings as *Forming of Materials, Machining of Materials, Inspection,* etc. Since these are in addition to a session on automation it would appear that this first conference will be searching, primarily, for those fundamentals which affect automation so considerably. While describing technological progress in such fields, authors will be asked to draft their papers to promote discussion on the practical application of the new or improved techniques of manufacture. It is also expected that indications will be given of the economies that can be achieved.

British companies have, of course, been installing automation for many years, but it was not until the Production Engineers Conference (June 1955) on the "Automatic Factory" that the public became aware that there existed a series of new methods called "automation". This awareness triggered off a considerable amount of newspaper talk and an outcry against possible labour redundancy. It is to be hoped that the sociological investigations of the Conference will help to allay these unwarranted anxieties. What we need in Britain is more automation in practice and less conjecture based on theory.

It may be added that Dr. Galloway is the Director of Research for the Production Engineering Research Association of Great Britain, a body which has been responsible for much research on the cutting of metals. His choice as chairman of the planning panel should ensure an eminently practical bias coupled with broad technical understanding. It is expected that the Conference will be able to canalise the information given and that it will be able to indicate where further information can be obtained.

Here and There

One important aspect of automation is the provision of plant which will, automatically carry out ancillary operations to promote continuous operation. Two such pieces of plant have recently been delivered.

The handling of scrap metal is not the easiest task in the endeavour to obtain continuous operation: moreover it involves heavy

Never a shutdown to oil this Welsh Plug machine because Farval's on the job

FARVAL—
Studies in Centralized Lubrication
No. 175

THIS machine drives seven Welsh Plugs into the block of a well-known automobile engine. Uninterrupted operation is essential to its smooth performance as part of the automated line.

That's the reason the builder installed Farval Centralized Lubrication. These photographs were taken before final assembly of the machine, to show the extensive, orderly arrangement of Farval lubricant lines and valve manifolds serving 207 vital bearings—failure of any one of which would cripple the operation.

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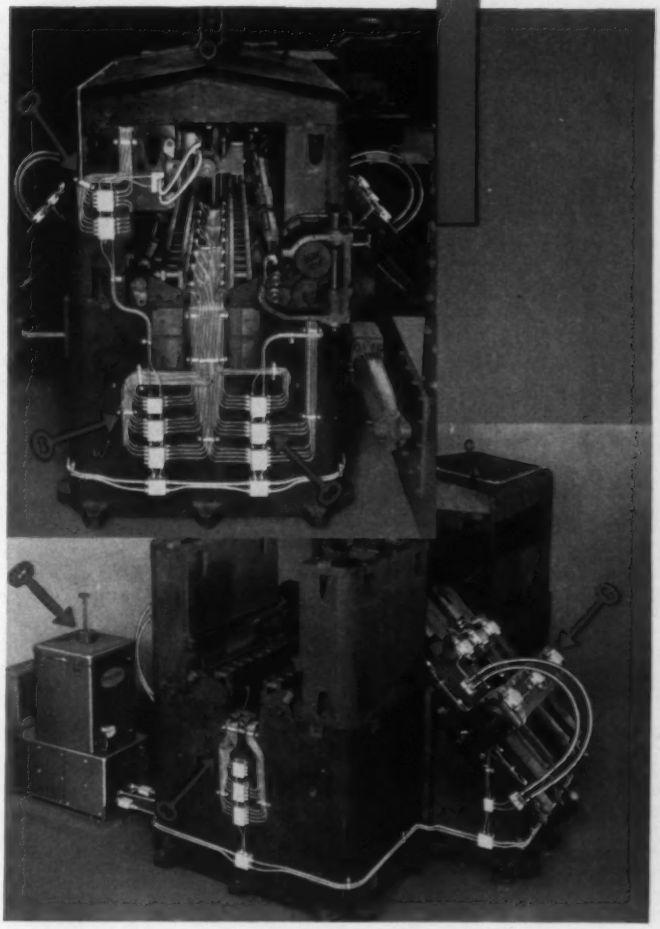
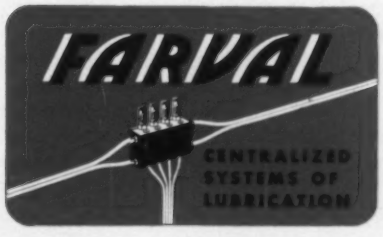


KEYS TO ADEQUATE LUBRICATION — Wherever you see the sign of Farval—the familiar central pumping station, dual lubricant lines and valve manifolds—you know a machine is being properly lubricated.

These photographs of a Welsh Plug Assembly Machine, showing Farval lines and valves on both sides, by courtesy of the builder, Sainte Claire Tool Company, Detroit, Michigan.



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Circle 670 on Page 17

manual work with some risk to personnel. To overcome this the Hymatic Engineering Co. has developed automatic loading hoppers, pneumatically operated, which increase the efficiency of the baling presses and reduce accident liability.

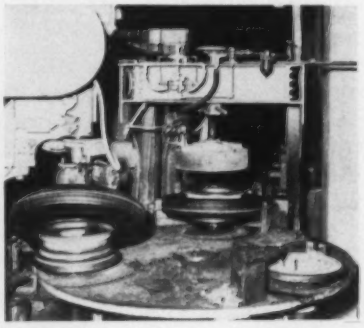
Various methods of bringing the scrap to the baling presses can be adopted, but in the case under review the loose scrap is deposited in a large well in front of two baling presses, both of which are fitted with the hoppers. A grab on an overhead crane fills each hopper in turn and since the time for compressing the bale is one minute, the grab and the presses are virtually in continuous operation.

The hopper is located immediately above the lid of the press. It is a simple box, the bottom of which is formed by two pneumatically operated doors. These, when opened, direct the scrap into the empty baling press. A counterweighted deflector flap prevents scrap being pushed over the edge as the press lid closes. On the top of the hopper there is a sheet metal deflector to guide the scrap from the grab into the hopper. As will be noted from the photograph, there is some over-spill from the grab, a fault which is in process of being corrected.

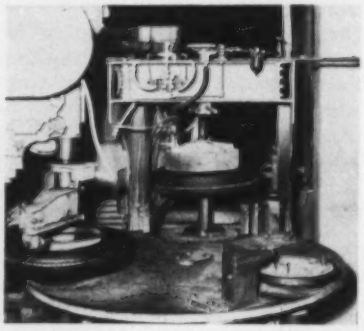
Following the discharge of a load from the hopper into the press, the sequence of operations is: 1. The hopper doors close. 2. The lock bolts to these doors are thrust home by a pneumatic device. 3. The baling press performs its task. 4. The grab refills the hopper as the press is operating. 5. The press opens. 6. The lock bolts to the hopper doors are withdrawn. 7. The press is filled and the cycle of operations is repeated.

Another Hymatic device, which assists continuity of flow, is machinery for fitting and inflating tubeless tires. There are two types: an in-line model and a 3-station rotary transfer model. The former is particularly useful when fitting wheels and tires of differing sizes. The method of operation is virtually the same in both types.

The wheels and tires are brought together by separate conveyors. An operator places a wheel on the table and puts a tire, loosely, over the wheel. This assembly is brought under a roller head which pushes both beads of the tire over the rim of the wheel, thus making it ready for inflation. It is then moved to the inflation station which has upper and lower platens between which the wheel and tire are inserted. A rubber sealing ring is embedded in the lower platen while the upper one is hollow so that air can be passed through it into the tire. The lower platen, operated by compressed



Fitting and inflating tubeless tires can be accomplished automatically by in-line or rotary transfer equipment. Illustrated is 3-station rotary type engineered by Hymatic Engineering Co. Tires and wheels are loaded at the empty station, tires mounted on the wheel by action of a roller at the second station, and inflated at the third station.



air, rises and seals the tire against the rounded edge of the top platen. A sequence valve then admits compressed air into the tire until a preset pressure, considerably above normal, is reached. The lower platen is then retracted producing an "explosion" of the tire into the rim. In this explosion, sufficient air is lost to reduce the air in tire to the correct running pressure. The wheel and tire assembly is pushed onto a conveyor and carried to the car assembly line.

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Circle 672 on Page 17

Cloak and Dagger

When going on record for their plant personnel or the public, management people often carefully explain that they are pursuing a program of intensified mechanization —not automation. With installations fulfilling the true sense of the word in every respect, the apparent contention is that a rose by any other name is bound to smell different.

Volumes of discussion have been recorded concerning precise definition for the word automation, but little effort has been expended in taking a vocal but thoroughly factual stand in spreading understanding of the subject. By avoiding the word, some managements appear to either believe the widely repeated scare myths or, like the ostrich, feel the wisest course is to hide one's head and perhaps no one will notice the activity.

Avoiding the subject in no way changes the character of the automatic equipment in the eyes of plant personnel. But full knowledge of the true and complete facts will help create the special climate needed for successful automation development. Wherever management has frankly and openly discussed automation plans with plant personnel, and the community, results have been outstanding.

Automation development is rolling under a full head of steam. It holds tremendous opportunity for the future, as developments have proved in the past. Responsible management must take the initiative and insure that the real message concerning their automation activity gets through. In the years to come, the stand taken by business management will be important: silence can only be interpreted as default; secrecy as a clandestine method; the cloak is suggestive of the dagger!

EDITOR

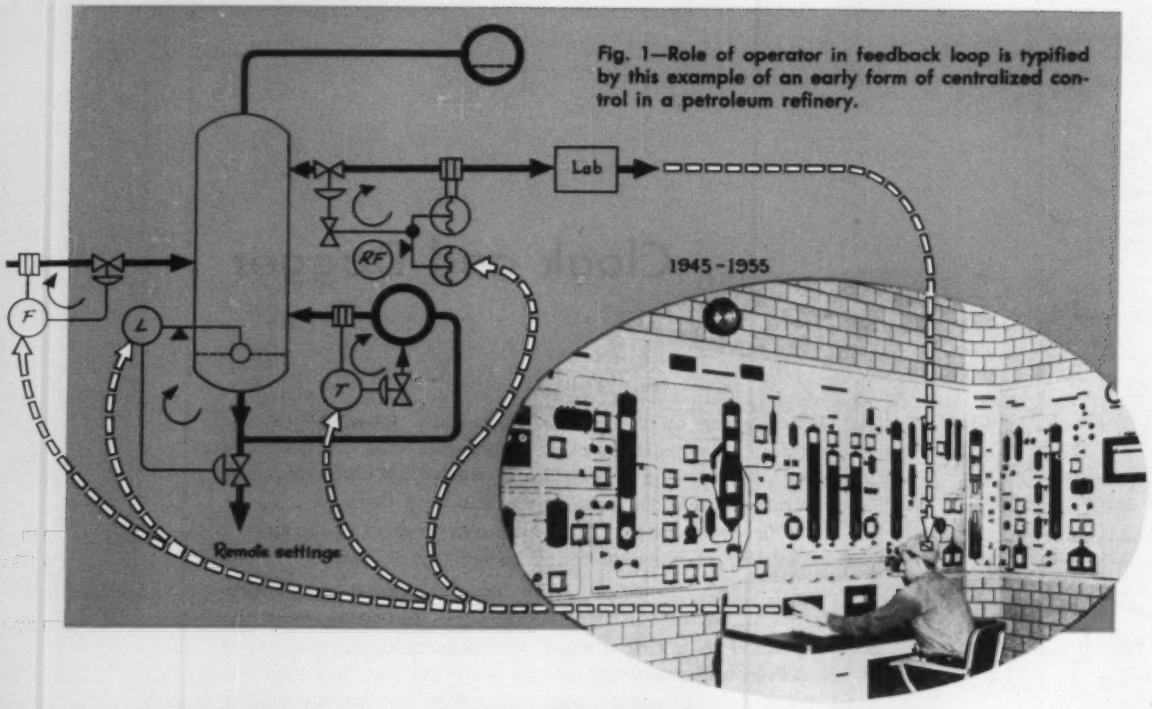


Fig. 1—Role of operator in feedback loop is typified by this example of an early form of centralized control in a petroleum refinery.

PROCESS CONTROL

EMPHASIZES INFORMATION HANDLING

Of importance in the overall field of measurement for control are the highly developed instrument systems used by processing industries. The author discusses such systems, emphasizing the area of interest common to both processing and manufacturing industries.

By **ALBERT F. SPERRY** President, Panellit, Inc., Skokie, Ill.

BOTH mechanization and control are important complementary elements of automation —but these elements have developed very differently in various industries because production problems in the industries are very different. In manufacturing, automation is basically the art of making things automatic, of mechanization. In chemical processing, however, processes are already so highly mechanized that automation means more effective use of feedback controls, regardless of whether they are automatic or not.

In the automotive and manufacturing industries, the big push for continuous production came about 25 years later than the process industries. Mechanized materials handling became the key to the modern continuous production line and the machines that have been developed to solve this problem seem little short of miraculous to those persons outside the manufacturing industries.

Manufacturing industries have been so involved with the colossal task of mechanization that relatively little emphasis has been placed on the problem of control. The chemical processing industries have had a very different history. Mechanization came to them very easily. The petroleum refining industries created a demand that could not have been met except by the development of the large scale continuous process. Materials handling

This article is based on a paper presented at the "Second Conference on Manufacturing Automation" cosponsored by AUTOMATION and Purdue University, October 1957.

presented difficulties because of the corrosive nature of the products involved, but they were child's play compared to the ones that confronted the manufacturing industries.

The petroleum refining industries had no alternative but to mechanize from the very start, and today practically no manual labor is expended in the handling or treating of their materials of production. On the other hand, entirely too much human effort is still expended in providing effective control of these processes. It is natural that the problem of automation is largely concerned with developing techniques of feedback control.

Feedback Control

Many names have been given to the principle of feedback closed loop control as contrasted with open loop. Cybernetics, the name coined by Norbert Weiner probably is the most apt, but it has not received the acceptance it deserves. Irrespective of its name, however, it has become well established that feedback control is the very essence of *successful* control in any field of human activity, and with such a practical problem as production for profit, then it is almost preposterous to conceive of control without some degree of feedback.

This does not mean that feedback need be automatic to be effective. As a matter of fact, there are very few processes of any complexity that are completely automatic today, not even the highly "automated" petroleum refineries.

The most general definition of feedback is "the governing of actions from current experience, rather than from expectations." This is goal seeking as contrasted with following a predetermined plan.

It has been said that there is very little feedback control actually used in the manufacturing industries. What is really meant by such a statement is that the machines themselves seldom embody automatic feedback devices. The feedback is introduced manually, often very ineffectively by inspection devices, and the like. This is still feedback, although it may be of a rather low order if it produces much nonspecification products.

Information for Control

The problem of feedback control is basically a matter of information. In order to effectively seek a goal, we must (1) define the goal, (2) be able to detect any error or deviation from the goal, (3) know what to do to correct the error, and (4) have effective means to make the correction.

The key to all four of these elements of control is information, or that part of the knowledge and data about the process that is essential to the problem in hand. All four involve the processing of information, but only the last one involves mechanization of the control loop.

If these factors can be quantitively established with sufficient accuracy, speed, and reliability, then the information is adequate and automatic control is possible. When the information is only partially available, then the experience and judgment of a human operator is essential to close the feedback loop.

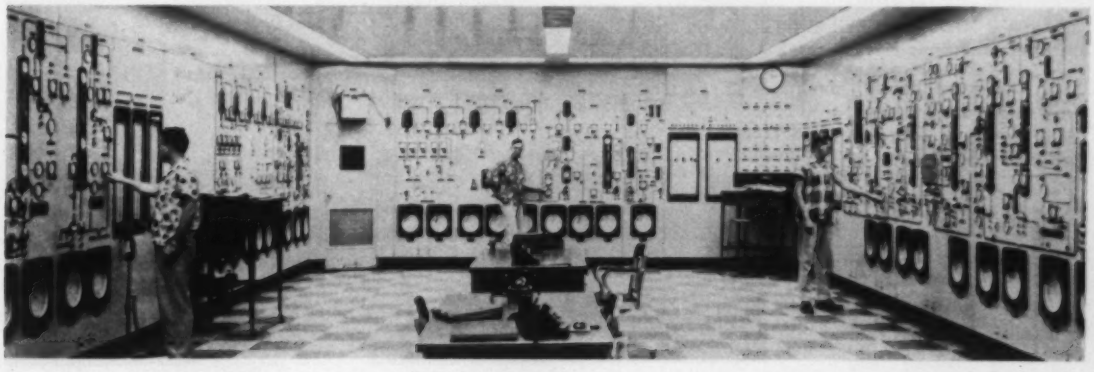
The process industries have been working on this problem of improving information for the last 50 years, and much of their progress can be traced directly to development of instrumentation and information handling techniques.

Four Stages of Development

This development can be traced in a general way through four rather distinct stages, starting from World War I, when the need for fuel conservation spurred the infant instrument industries to develop accurate flow metering devices. From then until World War II, measuring devices became so accurate and reliable that the automatic control of flows, temperatures, pressures, levels, etc. became standard practice. This made possible such developments as the continuous petroleum refining process, which has set the pace for the entire chemical industry.

In *Fig.* 1, such a unit process is diagrammed and every variable is shown automatically controlled, with the exception of the output quality. This is analyzed by a plant laboratory and once a day, or once a shift, a report is sent back to the unit oper-

Fig. 2—With continual development of the technique of centralized control, complex installations became feasible. The point was reached, however, where size created problems in co-ordination and efficient operations.



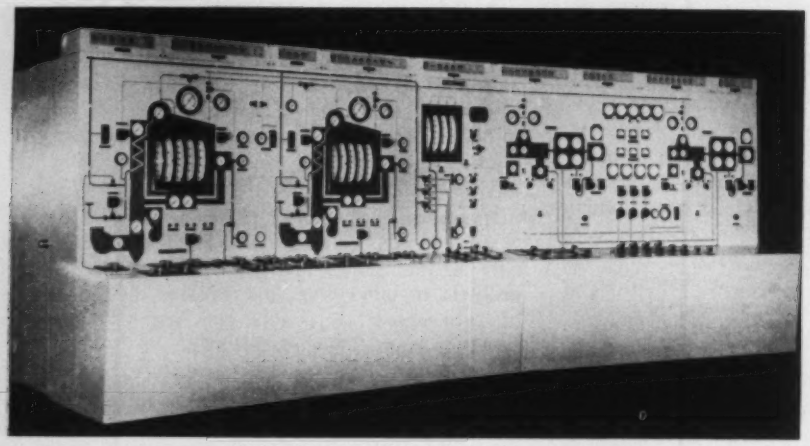


Fig. 3—Graphic control panel for a power station.

ator who readjusts all the controllers to keep the quality within specifications. If he is not successful, then the product has to be rerun or reblended to make it acceptable—an expensive mode of feedback control.

The recycle flow controller, labelled *RF* in *Fig.* 1, shows diagrammatically, how a unit controller can be part of both a local control loop and a larger operational loop at the same time. As long as the operator does not readjust the rembte set point from the graphic panel, it holds the recycle flow constant.

Note particularly that the controller does not register the absolute value of the flow. It only has to respond to the difference between the pressure on the two diaphragms, the deviation from the desired value, or the error. No calibration is required since the operator reads the actual flow on a separate meter.

This is the key to the successful use of feedback controllers. Since the absolute accuracy is controlled from a separate and larger loop, they can be built very simply and yet give extremely sensitive, fast and reliable response to the smallest deviation. Thus, it is quite common to find a temperature controller whose absolute accuracy can be relied on to only three or four degrees Fahrenheit, holding a top tower temperature within 0.1 of a degree Fahrenheit.

Going one step further to the larger control loop, it is not always necessary that the operator be able to read the temperature with that accuracy. He notes the laboratory report and continually adjusts the temperature until he arrives at a value that gives him the desired result in terms of quality. Again he need only have a thermometer that can detect setting changes of 0.1 degree Fahrenheit, and its accuracy is of no consequence to him.

This does not mean that accuracy is of no importance to control problems. The point is, accuracy is required only in the larger and more complex system loops, particularly when several variables are combined to form a single criterion for control. This kind of accuracy is difficult to attain and, therefore, these control loops can seldom be made automatic.

When a unit operation, such as *RF* in *Fig.* 1

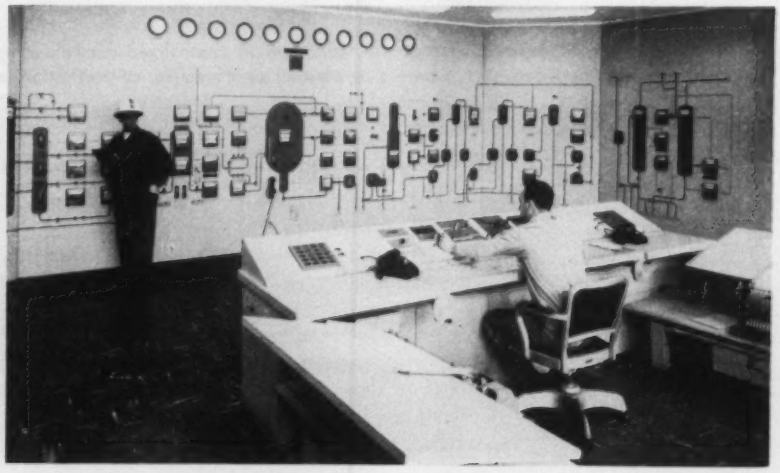


Fig. 4—Modern central control and information system at a Tidewater refinery. This should be compared to Fig. 2.

is to be controlled, however, the need for absolute accuracy disappears and it is possible to utilize a simple deviation controller, which is inherently fast, rugged and dependable.

Central Control

When World War II created demands for much higher production rates, processes and plants got so complex and spread out that it became impossible to control them even if there were two or three men per unit. Throughput became so high that storage between units sufficient to keep them running continuously would have been prohibitive in cost. With reduced storage it became impossible to operate each unit separately, and the need to put a great deal of information before one man became pressing.

The modern central control board was developed as a result of techniques borrowed from the military and, particularly, from the Atomic Energy Commission. Remote transmission of measurement and control signals, and miniaturization of instruments, made it possible to put so much information in a single control room that it finally became too much for one man to absorb.

The wide application of alarm and annunciator devices relieved the pressure on the operator considerably, allowing him to concentrate on the overall problems secure in the knowledge that his attention would be called to any abnormality that required his attention.

Finally, the development of newer and more complex processes made the operator's problem so difficult and, at the same time, created such a demand for new operators, that some means of work simplification had to be provided. The graphic panel was developed using visual aid techniques to make it possible for one man to understand and control the most complex of process systems.

The first application, *Fig.* 1, was a 25-foot panel installed in 1948, to control an entire petroleum refinery and this type of panel soon became common practice in the oil industry. Within the next few years it was widely adopted by the chemical, food, and even the power industries, *Fig.* 2 and 3.

All of these control boards are good examples of feedback control of continuous process in which all the variables are automatically controlled except for the final product—quality. This is entirely controlled by an operator who continually readjusts the settings of the various remote controllers on the graphic panel to keep the product quality up to specifications.

It is logical to ask why it has not been possible to build automatic analyzers that can replace the operator entirely. As a matter of fact, a tremendous effort has gone into the development of so-called "end point" analyzers since World War II, and many successful measuring devices have become available. Almost every physical quantity that might relate to quality has been thoroughly explored. Conductivity, pH, refractive index, nuclear dispersion and magnetic resonance, specific gravity, viscosity, boiling points, etc. are all being measured quite successfully. Spectroscopy using infra red, ultra violet, microwave and mass spectra are all readily available, and recently vapor phase chromatography has shown itself to be an extremely reliable and simple approach to the problem of quality control.

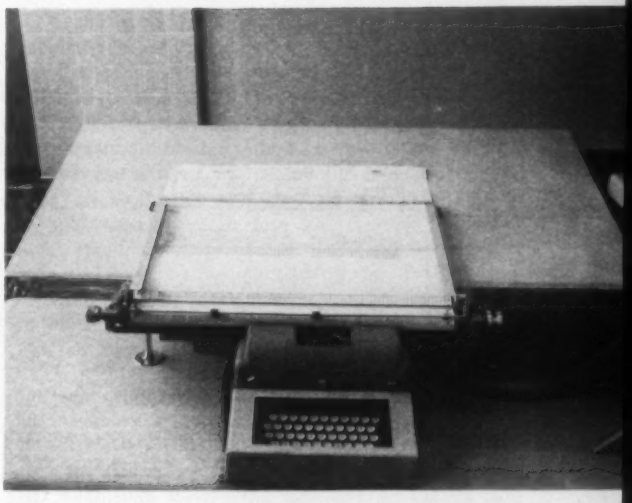


Fig. 5—Variables in a modern system are continually scanned and displayed on typewritten log sheets. When preset limits are exceeded, this information is immediately typed out on a separate section of the log sheet.

Two main obstacles have prevented these from fulfilling the requirement for automatic end point control, except for certain simple processes. The primary obstacle lies in the difficulty of obtaining a clean, representative sample on a continuous basis. The materials involved are extremely corrosive and usually very viscous, and the new products coming to the market keep getting more and more difficult to handle and sample. Therefore, while there are good accurate automatic analyzers available, the information we get from them is relatively poor because of the so called "noise" introduced by these sampling errors.

But even if good sampling became possible, another obstacle would prevent us from closing the loop automatically in complex process systems. This has to do with the third factor, mentioned previously as an essential to successful goal seeking, namely, knowing what to do to correct an error once it has been detected by the analyzer. In the complex systems such as petroleum refineries, there is no simple relationship between the outgoing product quality and the input flows, temperatures, or pressures that we adjust to maintain this quality.

Without this knowledge, automatic system control is impossible, and highly trained technical staffs are required to interpret the results of a product analyzer. They pass them along to an operator who controls his process by a sort of

trial and error series of adjustments, and the degree of success varies considerably with the skill and experience of the individual closing the loop. This is truly more an art rather than a science and the big problem ahead of us is to establish correlations and make a scientific approach possible.

Information Processing

In the last few years a new stage has developed—automatic information processing. The success of the new digital techniques in office machinery and in military work made it logical to apply them to process control. Automatic information gathering systems have been developed that have accomplished two objectives—they have extended the operator's scope to larger and more complex systems, and they have made data available to technical staffs much more quickly, more reliably and more accurately.

Fig. 4 shows a control board in a very large modern refinery combined with an automatic information system. The control board itself has been greatly simplified and reduced in size by omitting all information not directly needed for resetting and controlling the system. All other information is displayed on the two typewritten log sheets (shown in more detail in *Fig.* 5). The information system constantly scans the entire unit and if any of the 500 odd variables are outside of preset limits the machine immediately types out the information in a separate section of the log sheet.

The operator can concentrate on improving the efficiency of the process, and unless his attention is called to an abnormality he can forget most of the details and study the information in front of him to better his product quality and yields.

The machine performs a second function. While typing out the variables, which it does automatically every hour, shift and day, it also punches a tape which stores all the data in a coded form that can be readily fed into a digital data processing computer.

The tapes from the various units are brought to the central computing center and processed together with the data received from the analyzers in the control laboratory. These are given to the technical staff, who in turn send back instructions

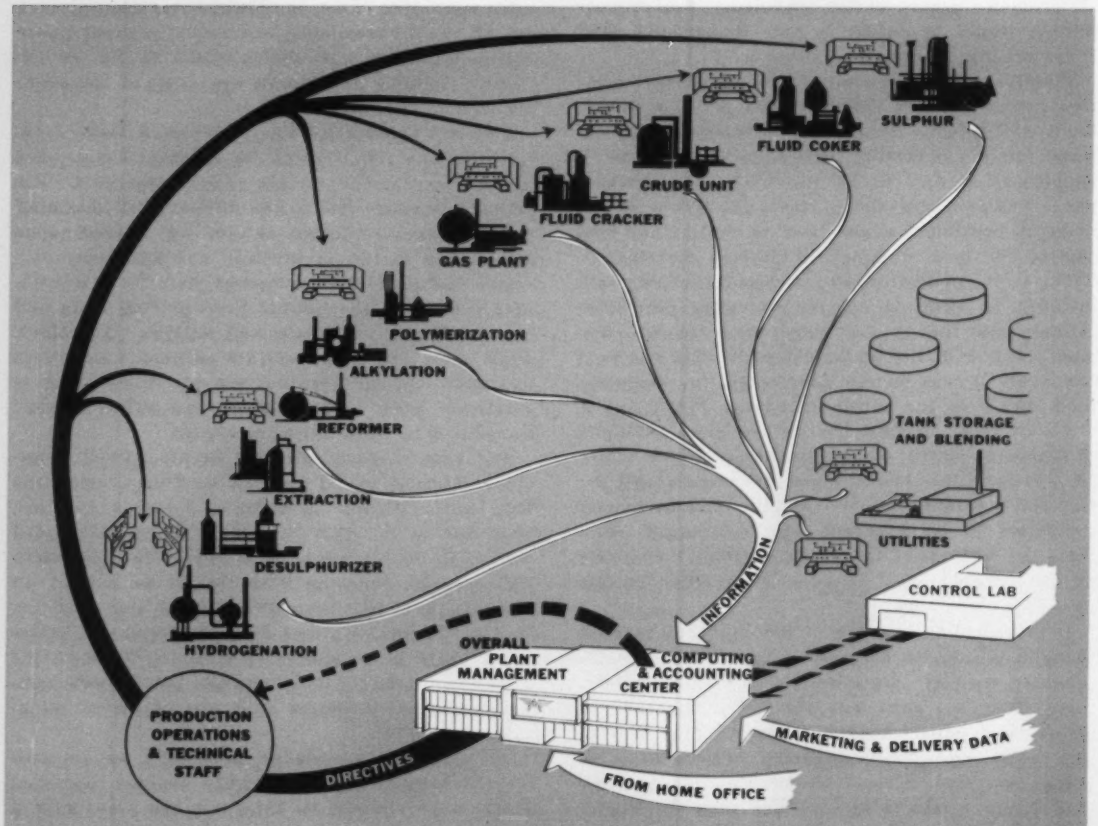


Fig. 6—Information flow is extremely important to process type industries.

to the individual operators. The instructions may give him the optimum rates at which he is to run his unit, the character of the crude materials coming into his unit, and many computations and production variables, too complex to determine readily in the control room. The condition of his catalysts, his product yield balances, the efficiencies of his heat exchange equipment, are typical of the type of information that can be of direct aid in improving yields. With data processing it will be possible to feed them to the operator regularly and quickly, not three or four days later as is usually the case, but within minutes and hours after the information is available, *Fig.* 6.

The big problem here again is the adequacy of the input information, and much of the effort today is involved in making it accurate enough to meet the requirements of the computing problems involved. Much greater accuracy is needed in many of these measurements since they may be used in a computation that depends on accurate input quantities and not merely for comparison with a set point as in the unit feedback controller.

Data feedback to the computer serves a third and vitally important function; it permits research to be carried forward on the full-scale plant. No amount of pilot plant investigations can substitute for full scale testing, and the mass of information that a data processing system makes available lends itself to study by statistical mathematical techniques. Correlation studies over long periods of time are one of the powerful tools to establish the relationships between product quality and input variables. It seems quite likely that the next few years of study may bring forth at least partial correlations that may go far toward making feedback control of complex processes more of a science than an art.

▶ The Future

What the next step will be depends somewhat on the degree of success with which we are able to establish the correlations discussed above. There is no question that digital computers, both general and special purpose, will play a central part in large-scale control systems. Considerable thought is being given to the possibility of using a computer as an "on-line" control device, receiving inputs automatically from a data gathering system, computing all the production variables and constantly readjusting the settings of the process controllers—in fact, a complete automatic plant.

Experimental installations of this type will probably be tested out within the next couple of years, but there is grave doubt as to whether or not the basic information exists to justify any hopes of success in the immediate future.

As a matter of fact, similar experiments are being made with analog computers, generally on simpler systems, and the recent improvements in accuracies in analog computers lend weight to the argument that they may be able to simulate plant operation accurately enough to form the basis for control.

It seems more likely that the computer will expand its role as an information processing device, taking the continuous stream of data from the information gathering systems and reducing this data to the simple production variables needed to manage large chemical plants.

This will include information for accounting purposes. In fact, cost control in such a plant might well become an hourly and daily feedback, rather than a monthly check of operations, as it is today. The only limitation is the adequacy of the input information, and here the very presence of a computer in the system will act as a catalyst, and force the improvement of measuring devices to meet the higher standards now required.

▶ Needs of Top Management

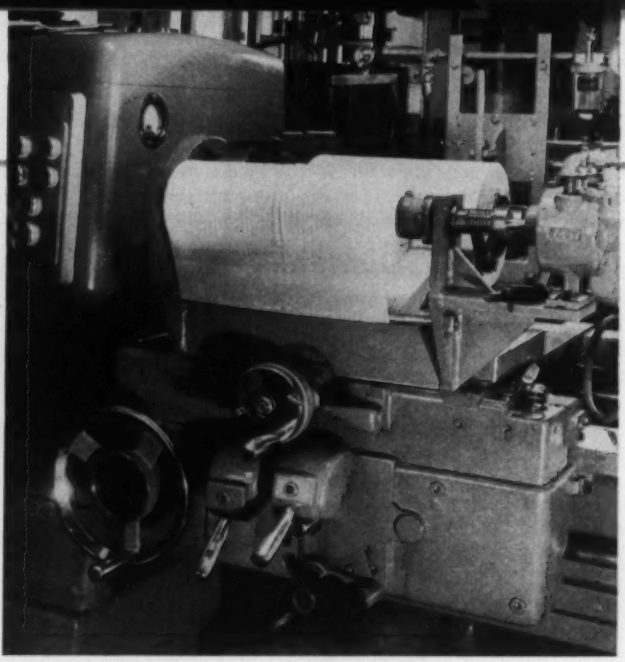
It must also be remembered that the needs of top management are changing because the very systems and plants that they are managing are becoming automated. As these plants get more continuous and more compact, they will be forced to operate on shorter time cycles, and this means tighter control and much more feedback of information. The amount of information that might well be needed in such an automated plant might be 100 or 1000 times as much as was needed for long-range accounting control.

The main function of data processing will, therefore, not be merely to give management the same information more quickly and more cheaply; it will probably be more accurate to state that the cost of information-gathering will be about the same, but the volume of work done will be multiplied many times.

If the information and control engineers grasp this opportunity they may not only supply this information but they may well be the ones who administer the operations that it describes. It has become popular to discredit the engineer as an administrator and, in fact, the whole role of scientific management has received much criticism recently. The emphasis is all on the human values, and the administrator of today is the man who can handle human relations problems. In the new automated plant, however, the engineering problems will be greater than ever, and it will not be quite as easy for top management to divorce itself from the technical operations of its system. This seems like a golden opportunity for the control engineer whose forte is handling tangible problems if given adequate tools.

Information processing may well be the tool that puts the engineer back in his rightful perspective as the administrator of these complex plants once he has developed the tools.

In conclusion, the management of large-scale operations, either processing or manufacturing plants, will place an ever-increasing emphasis on feedback control and information handling. Management will demand more of the control engineer, and if he can meet the challenge he will have forged for himself a tool which only he, as an engineer, can administer.



1

Lathe setup is employed at the Plastic Products Div., Raybestos-Manhattan Inc., to skive Teflon sheet from Teflon billets. Billet is mounted on the mandrel at rear of machine, and a knife skives the sheet from the billet. Sheet is taken up on roller at front of the machine. Raybestos-Manhattan has been able to produce sheet as thin as 0.001 inch by this process. The ability to thus skive thin sheet and to produce Teflon in different colors was a critical factor in enabling the manufacture of Teflon coated wire.

2

After the sheet has been made, the roll is placed on a slitting machine. A bank of knives in this machine slits the sheet to required tape widths. Tape is taken up on two banks of reels. Machine is capable of cutting tapes to a variety of widths ranging from ¼ inch to 18 inches.

3

In the use of Teflon tape as insulation on miniature wire for electronic circuit applications, such as in jet aircraft and missiles, the material must be in accordance with requirements of military specifications. Pictured here are a test for spots of low dielectric strength and a test for tensile strength and elongation. Tape used by Tensolite Insulated Wire Co. Inc. must withstand a 2500 psi pull with less than 400 per cent maximum elongation.

AUTOMATION TODAY

MAKING TEFLON INSULATED WIRE

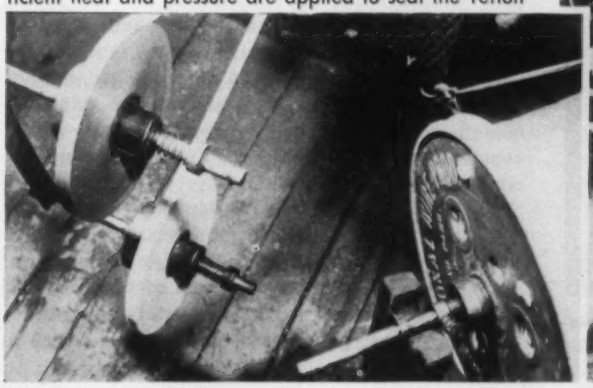
DEVELOPMENT of new products, of new applications for old products, and of new materials to be used in products all go hand-in-hand with the development of production techniques. Widespread application of a material often depends on industry's ability to devise the methods of manufacture necessary to accomplish the purposes for which a material's properties make it well suited.

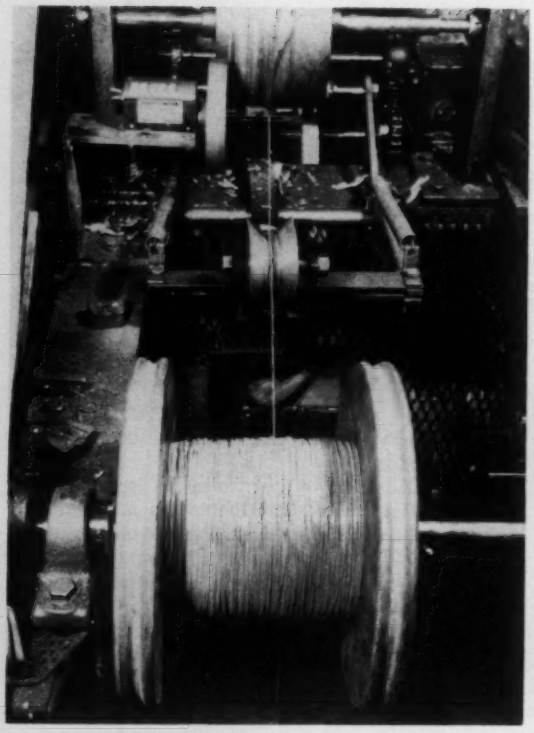
An interesting case study that illustrates the progress made by such developments is the use of Teflon tetrafluoroethylene resin as an insulation material for electrical wiring. This material has many advantages that make it desirable for this application.

It can withstand temperatures as high as 500F without deterioration. The insulation is essentially impervious to chemical attack and largely unaffected by the majority of temperatures that would be encountered in any installation in which such wire would be used. Also, because of high dielectric strength coupled with the heat resistance of Teflon, much smaller conductors can be used in Teflon insulated wire than would be required

4

Operator is shown making adjustments to a machine that employs the parallel wrapping process developed and patented by Tensolite to apply layers of tape over wire. For most applications stranded conductors are used to achieve greater flexibility. Specifications require that the wire be protected because bare copper oxidizes rapidly. Silver plated wire is used. Tinned copper conductors cannot be used because the melting point of tin is below the processing temperature of Teflon. Inset photo shows arrangement of spools on the feed-in side of the machine—wire on the right—tape on the left. Inner layers of tape, which feed from the bottom roll, are natural colored Teflon. Outer layers are colored. From the feed-in operation, wire and Teflon tape pass around a heated drum which applies tape to wire and fuses the several layers of tape together. Wire feeding onto heated drum is tightly twisted. Tape wraps around wire continuously. Sufficient heat and pressure are applied to seal the Teflon





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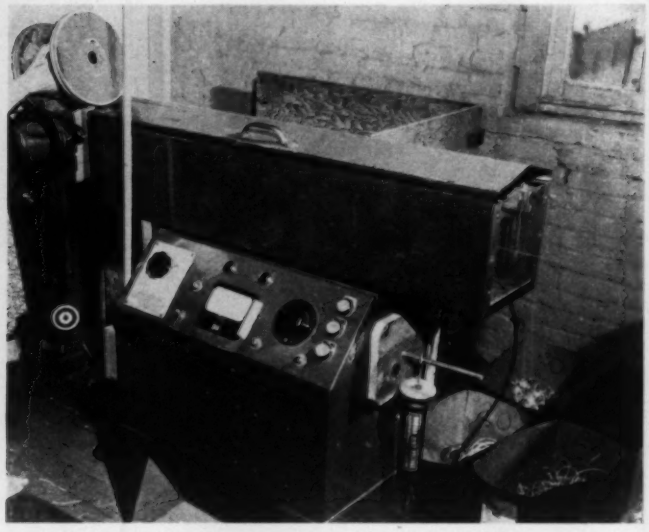
After the wire leaves the drum, through a series of pulleys, the twist is released. The finished product, pictured here being taken up on a reel, is a stranded conductor with multiple layers of Teflon tape parallel-wrapped around it.



6

All of the finished wire is run at a speed of approximately 200 feet per minute through this box. The box contains chains of beads through which 2000 to 8000 volts pass constantly. Whenever the insulation contains an imperfection, the voltage arcs through to the conductor, and the machine stops automatically so that the weak point in the wire may be clipped out.

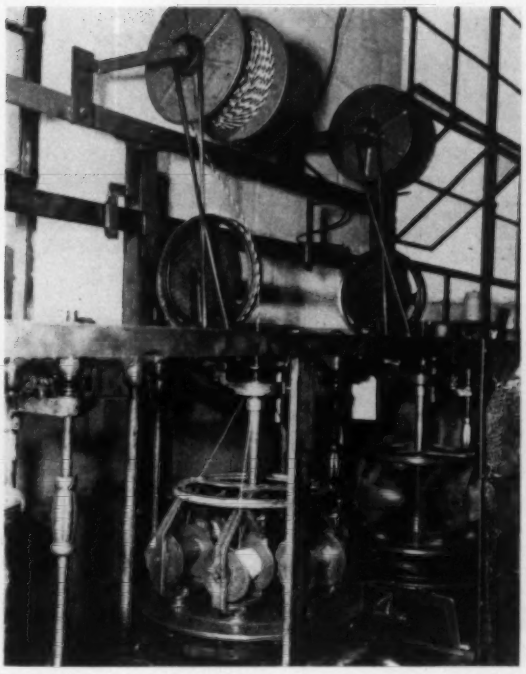
7

Operator rethreads the insulation testing machine after removing a weak spot in the wire. Bead chains are visible in the box.

for the same application with standard thermoplastic insulation.

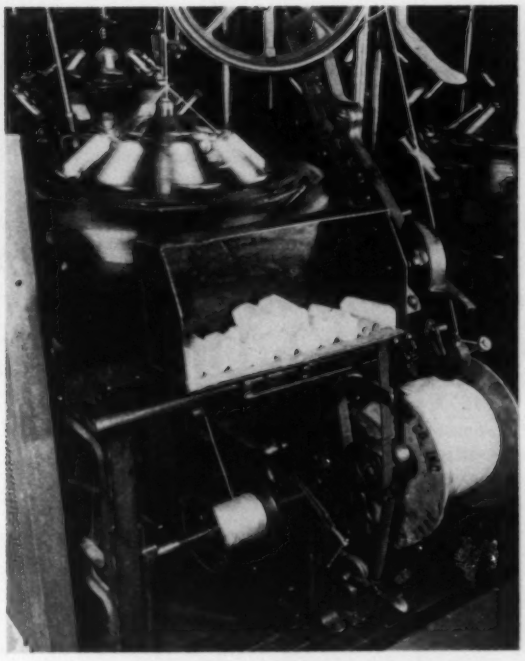
In addition to its other advantages, Teflon is unaffected by contact with a hot soldering iron. Standard thermoplastic insulation melts instantly on contact. Faulty soldered connections in complex circuits that have been wired with Teflon coated material can be resoldered without any fear of damage to any of the other wires, even if the soldering iron is in repeated or prolonged contact with the other wires. In standard thermoplastic coated circuits, repairing connections in places congested by wiring may require dismantling the circuits.

The only drawback to Teflon coated wire has been its price. It costs approximately 5 to 10 times as much as standard thermoplastic coated wire. For this reason the use of Teflon coated wire and cable has been confined until recently to installations in which guaranteed performance is more important than expense. These uses have been in



8

Multiconductor cable is twisted automatically on these machines. Four strand cable is being twisted here. Machine in the foreground is shown at rest; the machine behind it is shown in motion. These machines can twist multistrand cable at a rate of approximately 10 feet per minute. Tensolite operates 9 of these machines.



9

After multiconductor cable is twisted, it may be jacketed with a woven braid, a tape, or an extruded compound. The braids may be either metallic or textile. The tape is usually Teflon while the extruded compound is usually a thermoplastic. The machine in the foreground is braiding a textile jacket on the cable. The unbraided cable feeds on the machine from the spool at lower right. The finished, braided cable is taken up on the spool at lower left.

the electronic systems of jets and missiles and in the wiring of complex analog and other sorts of computing machines.

Use by IBM of Teflon coated wire in computer circuits and by Eclipse Pioneer Div. of Bendix Aviation Corp. in their transistorized flight control systems developed for use on jet aircraft for commercial transport are indicative of an increasing commercial importance of Teflon coated wire in spite of its price.

The ability to supply this product was contingent on several developments of manufacturing techniques. Tensolite Insulated Wire Co. Inc. had developed and patented a parallel wrapping process that for smaller sizes of wire allowed greater flexibility than extrusion or spiral wrapping methods. Having decided that Teflon offered great promise for high temperature applications, the company conducted experiments with Teflon tape and showed that it could be applied to wire by the parallel wrap process.

The problem then was that the only tape available was in the natural color of Teflon—about that of skim milk. Circuit wiring requires a selection of colors.

Tensolite asked the Plastic Products Div., Raybestos-Manhattan Inc. to determine whether colored Teflon could be made. Until then no manufacturer had succeeded in coloring the plastic. Raybestos-Manhattan agreed to attempt to color Teflon and succeeded in doing so by August 1952. The following year Teflon covered wire was available in all ten standard NEMA colors plus four extra colors required by the industry.

These developments have made available a product having greater reliability, whose weight and volume are 1/3 to 1/10 as great as other coated wire that would be specified to do an equivalent job. Where 22 gage wire had to be used when the coating was a thermoplastic compound, 26 gage wire can be used where the insulation is of Teflon. Reduction of outside diameter in such a case is from 0.060 inch to 0.039 inch.

Steps in the processes of making Teflon tape and making Teflon insulated wire and cable are shown in the accompanying photos.

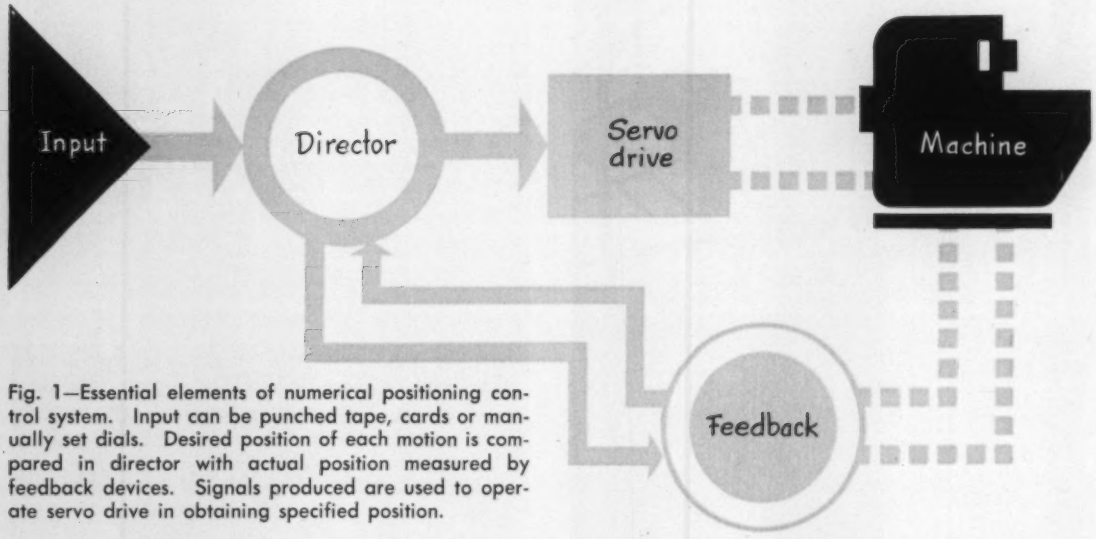


Fig. 1—Essential elements of numerical positioning control system. Input can be punched tape, cards or manually set dials. Desired position of each motion is compared in director with actual position measured by feedback devices. Signals produced are used to operate servo drive in obtaining specified position.

FOR PLUS ADVANTAGES SPECIFY

NUMERICAL CONTROL

One of the most recent developments in automation of operations is numerical control. This discussion indicates what it is, why and how it is used, and benefits to be realized by its use.

By **GLENN R. PETERSEN,** Mgr. Program Control Sales, Specialty Control Dept., General Electric Co., Waynesboro, Va.

NUMERICAL CONTROL can be defined as "the automatic operation of machines or processes from numerical information." Such a definition actually describes a numerical control system, of which the control unit at the machine or processing equipment is only one element. The distinguishing characteristic is that numerical information describing the desired operation is presented to the system, and it is then processed to varying degrees until the specified operation results. The data processing may occur only at the control unit or in auxiliary equipment, but no further manual manipulations of the data are required after the initial presentation. Thus a numerical control system can automatically operate a drilling machine from a numerical description of hole locations or a contour milling machine from equations defining the surface of the part to be cut. Numerical control techniques could be applied to chemical and other continuous processes as well, but since the bulk of current interest—and experience—is in the field of machine tools, this discussion will be confined to that area.

The impact of numerical control on industry has already been substantial, and a look at a few of its potential benefits quickly shows why. Visualize a machine which operates automatically from data automatically recorded away from the machine. Visualize a machine which repeats its operations over and over without change. Visualize a machine which runs at speeds several times faster than normal. These are a few of the abilities numerical control imparts to the machine and which mean benefits to the user, such as:

1. *Higher machine productivity.* Reduced setup time and increased operating speeds give more machine output.

2. *Improved product quality.* Reduced operator contributed errors and improved accuracy of machine operation result in better quality.

3. *Shorter lead time.* Elimination of many special templates and tooling reduces time lag between

This article is based on a paper presented at the "Second Conference on Manufacturing Automation" cosponsored by AUTOMATION and Purdue University, October 1957.

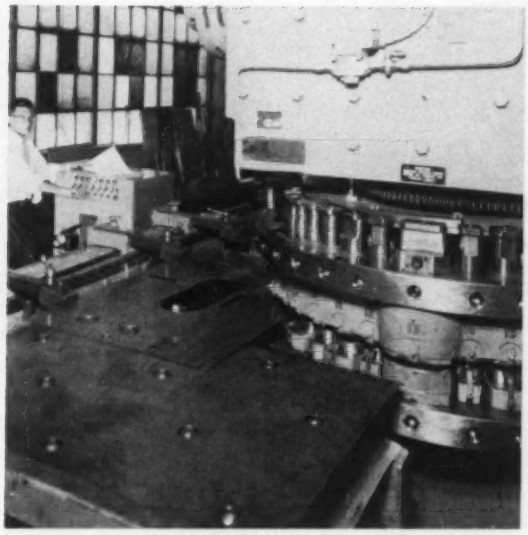


Fig. 2—In-out and crosswise motions of the table plus rotation of the turret are automatically controlled by positioning control system in accordance with instructions presented on punched cards. Overall production increases have averaged 60 per cent.

finished drawing and finished part.

4. *Lower inventory.* Ability to produce parts in almost any quantities at substantially the same cost allows production of parts as needed, lowering inventory of finished pieces.

5. *Lower costs.* Consistency of operation of numerically controlled machines reduces scrap losses and, coupled with faster operation, reduces operating costs.

6. *Reduced investment.* Higher production rates plus reduced floor space requirements lower the investment in plant and equipment.

In order to understand how numerical control can be applied it will help to know a little more about it and how it has been utilized to date. First, it can be divided into two general classes: numerical positioning control, which involves the point-to-point positioning of controlled motions which move independently of one another; and numerical contouring control, in which the controlled motions are related to one another so as to produce a particular tool path along the work piece. Of the two, numerical positioning control has the widest range of applications, although the more complex contouring control is more spectacular in operation. To understand them, they must really be looked at separately since their uses are quite different.

▶ Numerical Positioning Control

NPC is exactly what its name implies: A system which positions machine motions to particular locations. Numerical data are usually presented on a storage medium, such as punched cards or paper tape, as actual dimensions from a fixed reference point. It may also be manually fed to the control by means of switches or dials. The control system includes position feedback devices which indicate machine position, a comparator which compares actual with desired position and produces an error signal, and servo drives to move the controlled motions to the proper point. Equipment is usually simple and relatively inexpensive and, in general, the only auxiliary equipment required is a standard tape or card punch. In addition, it is easily applied to a wide variety of machine tools and can be readily integrated into most manufacturing operations.

Cards or tapes are usually prepared in a planning office where the planner, working from part drawings, tabulates the required positions for each motion and notes any special requirements such as feed speeds, tool changes, etc. A clerk then types up the cards or tapes which go to the shop floor with a planning sheet containing any special operator's instructions. The operator makes the necessary machine setups and follows any special instructions called for by the control data, but all machining operations are performed automatically, *Fig.* 1.

Examples of NPC in operation are as follows:

Punching: An 80-ton rotary-turret punch press was equipped with NPC in 1954, and has been used since that time for punching formed holes in flat sheet steel for switchgear cases.

The machine includes two table motions—in-and-out and crosswise. The table carries the steel sheet between the upper and lower turrets containing 32 combinations of punches and dies. The punches and dies are selected by rotating the upper and lower turrets which are driven by a single motor. Prior to the installation of numerical positioning control, the operator manually positioned

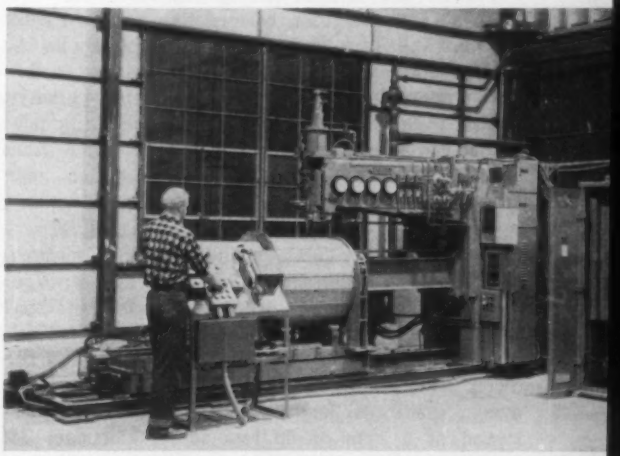


Fig. 3—This automatic spot welder has one linear and one rotary motion controlled from information supplied on punched paper tape. Automatic machine has given production gains as high as 8 to 1 over previous manual operation.

each table motion by hand wheels while simultaneously observing position-indicating ruled scales.

Now, with numerical positioning control, the operation is greatly simplified. The operator places a stack of cards in the card reader and initiates the control. The first card directs the table motions to the loading position and stops the machine. After clamping the steel sheet on the table, the operator presses the *START* button. All positioning and punching are completed—automatically to an accuracy of ±0.010 inch at speeds up to 450 ipm.

Increases in positioning efficiency have ranged from 300 to 500 per cent depending on the size of the workpiece and number of holes to be punched. An overall increase in production, including loading and unloading, has averaged 60 per cent, *Fig.* 2.

Welding: A recent application of NPC is on an automatic spot welder used to weld tabs on cylindrical tail pipe liners for jet engines. In this case, punched tape carries the data used to automatically control the welding of a series of tabs along the surface of the liner and parallel to its axis, *Fig.* 3.

When the workpiece has been secured in the fixture, the operator initiates the control to read the first block of information on the punched tape. The control selects the proper heat and weld time and transverse fixture position for the first weld. It positions the rotary and longitudinal motions at 150 ipm in sequences as selected from the tape to an accuracy of ±1/64 inch.

A typical part made on this machine requires 1650 separate welds. Change over to the automatic machine from the previous manual operation has resulted in about an 8 to 1 time saving.

Drilling: Another application of NPC is for control of a drilling, spotfacing, and chamfering machine on which two motions, vertical and rotary, are controlled, *Fig.* 4.

A horizontal spindle is positioned vertically on a column mounted on a base section equipped with ways. The rotary movement is provided by an indexing table on which the work is mounted. Vertical traverse of the drill head is guided by ways on the column and driven by a ball-bearing precision lead screw. Rotary movements of the table are developed by a motor-driven precision gear and pinion.

Cycle of in-and-out movement of the vertical drill head and column includes rapid approach, two rates of feed, three depths of penetration, and rapid return. The system controls the actuation of the cycle, selection of feed rate and depth of penetration, and inclusion or omission of the dwell. Vertical motion of the drill is programed over a maximum length of 30 inches and is positioned at a rate of 60 ipm to an electrical accuracy of ±0.0005 inch.

Turning: A rather unusual application for NPC was made on a step-shaft turning lathe. Since the parts require only straight cuts parallel to the shaft axis or shoulders vertical to the axis,

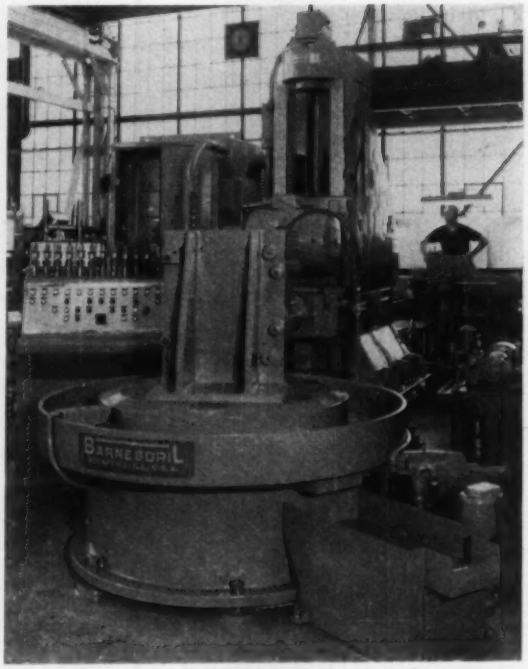


Fig. 4—Punched tape used as input for this numerically controlled drilling machine includes positioning information as well as feed rates, tool selection and various cycle selections. Electrical accuracy is ±0.0005 inch at feed rates of 60 ipm.

only one motion operates at a time which allows the use of NPC. Control is from punched cards and includes selection of spindle and feed speeds in addition to control of the cross slide and carriage position. Electrical accuracies are ±0.0025 inch on the carriage and ±0.0005 inch on the cross slide.

Actual production performance of this machine has been excellent. The parts were formerly made manually requiring frequent stops for measurement and gauging, or on tracer lathes which required templates. The use of NPC has practically eliminated machine setup time and reduced the cost of data preparation 10 times. Average time savings range from 51 per cent to 83 per cent depending on the part, *Fig.* 5.

Milling: One of the most spectacular applications of NPC has been a punched card system controlling 15 separate motions on a special milling machine.

The machine is used for a variety of milling operations, for slug inserting and spinning on extruded sections of copper. These extruded copper sections consist of a ribbed body and a cover which fit together to form a hollow electrical conductor. Conductors and conductor covers are clamped side-by-side on a 30-foot-long work table. Six traveling carriages move over the work table performing work on conductors and covers simultaneously. A deburring carriage moves across first to clean the work. It is followed by a second carriage with a slug-insert head which places 1-

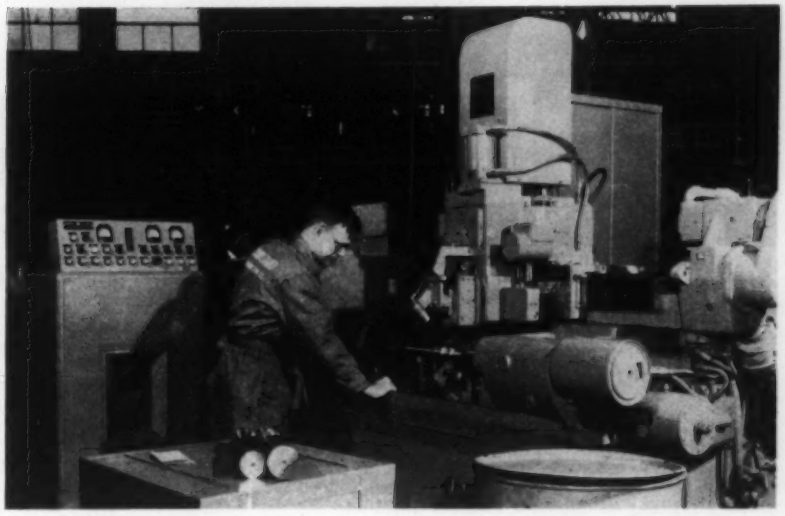


Fig. 5—Experience with punched card controlled lathe indicates major savings are in machine setup time and data preparation time in comparison to manually operated or tracer controlled lathe. Overall time savings have ranged from 51 to 83 per cent.

inch slugs in correct position in the rib sections of conductors. A spinning head on this second carriage stakes plugs into place. Remaining carriages perform taper and side-port milling, rib removal, and cutoff operations.

Each carriage has a cross feed which positions the heads transversely with respect to the work table and a longitudinal feed which positions the carriage at 300 ipm to ±0.005 inch repeatability. The entire operation, including the work of subsequent carriages, is done automatically. The operator merely monitors the operation.

Auxiliary programed functions include card sequence check, taper selection, angle milling head selection, selection of preset traverse or feed speeds—a total of 12 in all.

These few illustrations show the wide variety of machine types which can be controlled by a numerical positioning system—and suggest the cost savings which such a system can provide. In general, the savings will appear particularly in the areas of machine setup and machine operating times, but other gains in accuracy, reduction in special tooling requirements, reduced scrap, and lower inspection costs can be anticipated. Wherever a machining operation requires positioning, there is a potential application for NPC.

▶ Numerical Contouring Control

NCC could be described as an NPC system in which the required positions are an infinitesimal distance apart. This is true, but to accomplish this objective requires a system which is somewhat more complex, both in the control elements and in the data processing required. Most of the interest to date in this type of control has been in the aircraft industry, which will have about 100 numerical contouring machines in operation by the end of 1958, but ultimately NCC will find application in all industries where contour milling is required.

A typical numerical contouring system requires a computer, an interpolator, and a machine control; although these functions are combined in various ways in some systems so that three separate devices are not required. In all cases the functions remain the same. The control unit at the machine is similar in function to an NPC unit, except that it must provide continuous control of all motions relating them so that the desired tool path is produced, *Fig.* 6.

The first step in using a numerical contouring system is to define the part to be cut numerically. This is done manually by a part programer who works from engineering drawings, handbooks or other part information. He first determines how the work will be located on the machine, what tooling will be used, how the cuts are to be made, and the required speeds and accuracies. He then prepares a chart listing this information plus a description of the surface to be cut. This data includes the co-ordinates of the beginning and end of each section to be cut and a definition of the section as a straight line, circle, ellipse, etc. The information is then punched into a tape or set of cards for insertion into a computer.

Since machine position is actually measured from the center of the tool rather than its surface, it is next necessary to determine the desired path of the tool center. This is normally done in a large, general purpose computer which calculates the location of the tool center, factoring in the size and shape of the cutter. The computer also calculates allowable accelerations and decelerations.

The computer output describes the tool center path either as a series of velocities or as segments of straight line paths, including the time for each section. This information must now be interpolated and broken down into an almost infinite series of points through which the tool center will pass. This may be done in the compu-

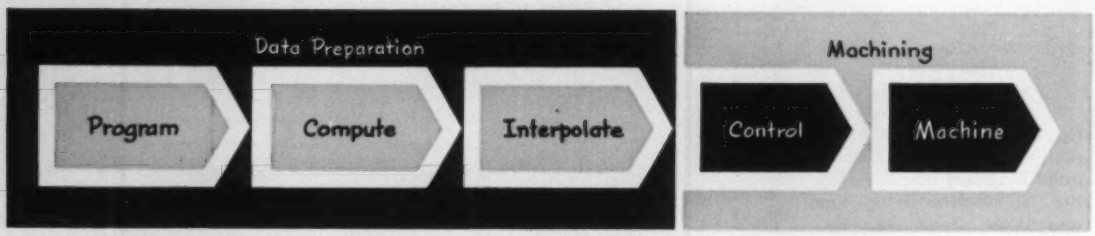


Fig. 6—Complete numerical contouring control system includes provisions for various data processing steps which precede control of the machine. The programing step defines the part numerically, and the computing step establishes the tool center path. Interpolation then develops continuous positioning information for the actual control of the machine.

ter, but is usually handled in a separate equipment or in a section of the machine control unit.

The final step is then actual control of the machine from either the computed or the interpolated data which are presented to the control in the form of punched tape, punched cards or magnetic tape. Function of the control is to continuously compare the actual position of each motion with the desired position and move the feeds to eliminate any position errors. The input information includes an element of time so that positions are called for in relation to one another in order that a particular path is produced.

The first applications of NCC were to a large aircraft skin mill and to a small cam milling machine. In both cases, the parts involved complex curved surfaces which were previously made on tracer machines using hand-made templates or models. The use of NCC removed this requirement and greatly simplified the problems of setting up and running the machines. Resultant gains in accuracy plus the reduction of lead time by as much as 90 per cent graphically illustrated the advantages of NCC.

Additional numerical contouring machines are now being put into operation, but no performance data are available yet. However, an indication of the potential benefits can be seen in the results of a survey made by the AIA using a small test piece requiring contour machining. Such a part would normally be made on a tracer controlled milling machine, and tests were run using both tracer and numerically controlled machines.

Making the template required 100 hours, including necessary paper work, while the milling operation took approximately 3½ hours. Preparation of the data on a computer for a numerical contouring machine took 2½ hours and the part was machined in just under 1 hour. Incidentally, the same part was later cut on another numerical machine in only 18 minutes. While such spectacular gains will not necessarily be realized on all parts, they give a good indication of the results obtainable with numerical contouring control.

Numerical controls, properly applied, can produce real savings for their users. But they may

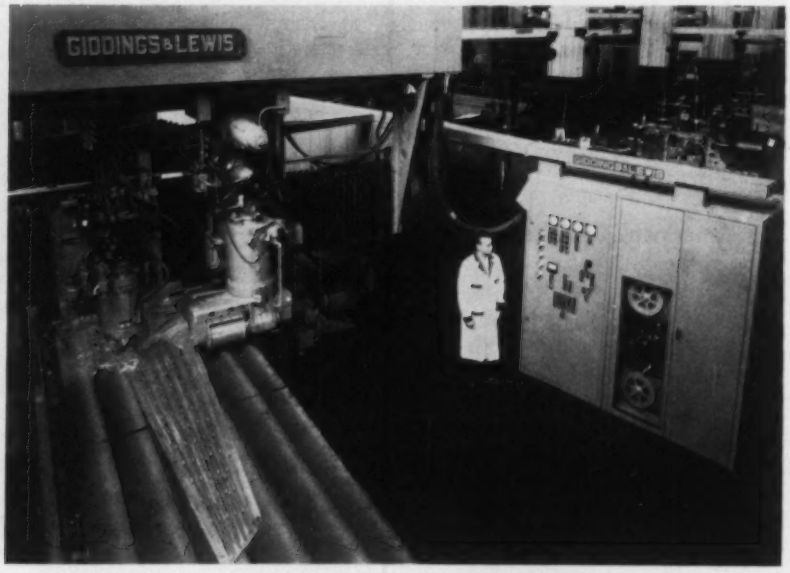


Fig. 7—Five motions are automatically controlled from 1 inch wide magnetic tape prepared on a separate director. This was the first numerically controlled skin mill used for actual quantity production of aircraft parts. Machine contains provisions whereby, when operated manually or under tracer control, a magnetic control tape can be prepared.

also require some changes in thinking, in procedures, and in personnel if the maximum available gains are to be realized.

The problems of machine and control reliability become very important when a change to completely automatic operation is made. The increased machine productivity which numerical control can give may result in the elimination of several older machines, but it may also mean that the new machine is the only one available for certain types of work. Both machines and controls must be designed to give good, continuous performance without breakdowns or long outages for maintenance. At the same time, they must be built so that required maintenance can be performed quickly and easily.

User maintenance people must be capable of working on electronic equipment, and this may require the development of new skills on their part. The day of the electrical maintenance man who simply changed brushes on motors and cleaned contacts on breakers is past. Good preventive maintenance programs will be required to keep unscheduled down time to a minimum and get the maximum benefits from numerical control.

Production procedures will undoubtedly change since long lead times will not be required. It should also be possible to build parts in smaller quantities, economically, which will lead to a change in inventory requirements.

There will undoubtedly be a number of changes in engineering and drafting methods — some of which will be mandatory. Programming for NPC, for example, usually requires that all dimensions be given from a common reference point. If drawing practices call for dimensioning between consecutive points, this should be changed to help the programer. Rotary motions are usually controlled to decimal parts of a degree, so drawings should not list minutes and seconds of arc.

For NCC, it will probably be desirable to use curved sections which can be defined by equations rather than an arbitrary portion of a French curve. If a part has a number of fillets it will be helpful to make them all with the same radius, and on some systems parabolic curves will be easy to program and should be used wherever possible. Actually, it is not unrealistic to visualize the day when many drawings which are now required will be completely replaced by a table of numbers and equations defining the part.

The job of the part programer is a new one which combines the skills of several functions. He must be familiar with machining practices, with machine and tool capabilities, and with fixture requirements and be able to convert drawing dimensions to a numerical description of the part in accordance with established procedures. In some cases, he may also be required to be familiar with, though not an expert on, the use of a computer. Men with this combination of knowledge and skills may be available in some organizations, but more often they will have to be trained for the job.

▶ Additional Changes

Inspection practices will undoubtedly change, and certainly 100 per cent inspection of parts produced on numerically controlled machines will not be required. Ultimately, it may be the practice to inspect the program and the first part produced. If these are correct, all subsequent parts would be the same except for variations introduced by tool wear, changes in the machine, warping of the part, etc. Incidentally, the programer can specify tool changes at planned intervals if this is required.

These are a few of the factors to be considered in using numerical control. There appear to be no insurmountable problems or sweeping changes which will be immediately introduced by numerical control. Rather, there will be some minor modifications necessary, and other changes which will evolve as experience directs and which will be instituted because they can further improve operations. The contributions which numerical control can make in improving efficiency and reducing costs are substantial. The equipment and techniques are available and being used by some manufacturers. They are ready to be used by all.

RUBBER PELLET STORAGE

HANDLING and storing material can create special processing problems if the material is sensitive to pressure. Exemplified by an initial installation for a rubber processor, special equipment has been developed by Richardson Scale Co. to prevent pellet adhesion during storage and handling. The initial installation includes a vertical series of straight-sided bins, each of which holds a specified quantity of the rubber pellets. The bottom of each bin is a pneumatically operated discharge gate mounted on rollers. Eighty such bins, arranged in 8 stacks over 4 automatic scales, comprise the installation.

In operation, pellets coated with talcum are delivered from the pelletizing operation by pneumatic conveyors to a feeder located above the top bin in a stack.

When the first bin beneath a gravity feeder is full, a diaphragm type flow control switch is actuated, allowing the pellets to drop into the next lower bin. The same transfer sequence is followed through succeeding bins until the bottom bin in the stack is reached or until a bin is reached that already contains the desired amount of pellets. Thus, pellets are stored in bulk but the weight in any one bin is effectively controlled to prevent adhesion by compression.

LOG CHARGER SPEEDS LATHE LOADING

MOST VENEER cut and used by the plywood industry is produced on large lathes which hold and revolve a log between two chucks while a knife is slowly advanced by a knife carriage to cut a continuous sheet of veneer having uniform thickness. Such lathes are made in a range of sizes suitable for handling log sizes encountered in any part of the country. They incorporate a gearbox which provides for advancing the knife carriage at different speeds in relationship to lathe spindle rotation so a desired thickness of veneer may be cut.

Early veneer lathes were loaded with chain falls. As years passed, various refinements in log loading were developed. Often, air hoists or electric hoists were employed and mounted on a monorail spur running over the top of the lathe. Special log tongs which engaged the logs over the ends were used in such arrangements. Considerable jockeying was necessary, however, to get the log into a position where both ends were properly centered with respect to the lathe chucks preliminary to dogging. The lathe, a large and costly machine, was thus idle during a lengthy loading period.

Practices developed over the past few years involve the use of special log chargers. Such devices mechanically place logs in the lathes, and the logs may be accurately pre-positioned before they are placed between the chucks. Different designs of log chargers have been built and put into use; most of them are floor mounted, but some are overhead machines, traveling on overhead runways. Generally, a floor type machine is used unless severe restrictions in floor space demand employment of an overhead charger.

Log chargers have usually been developed and built by firms other than those making the lathes. The lathe shown in *Fig.* 1 was built by Merritt-Solem Div., Solem Machine Co., and the log charger was built by Globe Machine Mfg. Co. Inc.

The logs are brought in by crane and deposited directly on the chain tracks of the lathe charger. Whenever the charger operator is ready for another log, he throws a switch, which causes the chains to advance a log to a stop. Then he positions the charger arms in front of the stop, releases the stop, and the log is rolled into the cradles of the charger arms.

The entire charger carriage is then advanced toward the lathe but is stopped at an arrangement of mirrors and lights. Spotlights at the two sides of the charger are mounted on standards and positioned so as to throw their light beams along a common line, toward each other. Positions of the spotlights are such that this light beam is parallel with the line of centers of the lathe chucks. Therefore, bringing each end of the log to a point where the spotlight centers on it, actually positions the log for the chucks while it is still resting in the charger-arm cradles. The charger operator accomplishes this positioning by watching the light spots on the ends of the log and manipulating controls which independently adjust each arm of the charger. Positioning in the charger is performed while the lathe is cutting veneer from the preceding log. Thus, as soon as a log core has been discharged from the lathe, the charger operator advances the log-charger carriage into the lathe and the log is automatically brought to proper position for chucking without any further manipulation.

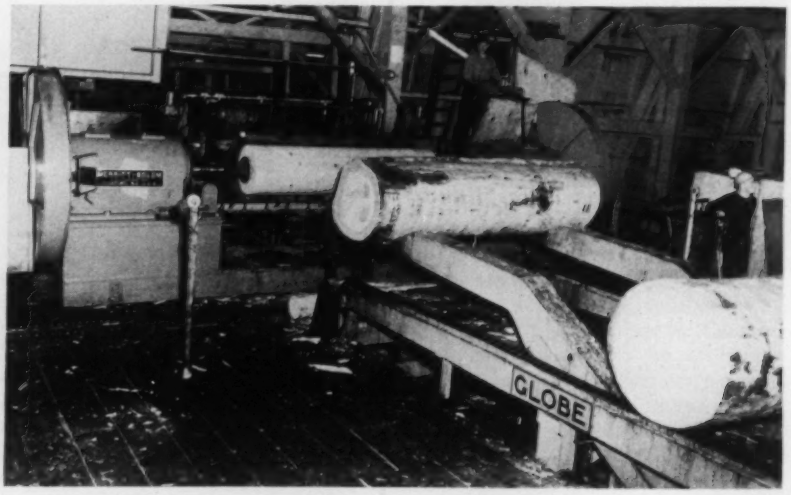


Fig. 1—Veneer lathe at C. D. Johnson Lumber Co. Div., Georgia-Pacific Corp., is speedily loaded by log charger in which logs are pre-positioned for chucking. Positioning is performed by charger operator at right who observes location of projected light spots on each end of the log and adjusts the charger arms.

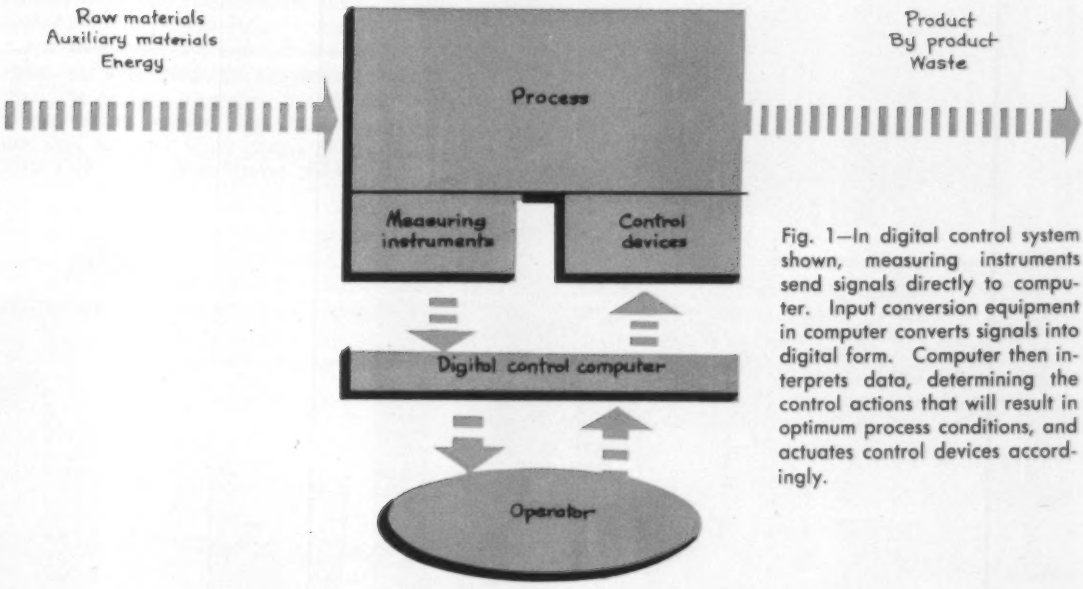


Fig. 1—In digital control system shown, measuring instruments send signals directly to computer. Input conversion equipment in computer converts signals into digital form. Computer then interprets data, determining the control actions that will result in optimum process conditions, and actuates control devices accordingly.

COMPUTER CONTROL

CLOSES THE LOOP

Introduction of digital computers into the control loop of continuous and batch processes promises attainment of degrees of automation and process optimization impossible by manual control. Here are described some of the capabilities and uses of process control computers for industry.

By GILBERT C. CLOSE Hawthorne, Calif.

CONVENTIONAL control of continuous and batch processes such as those employed in the petroleum refining, chemical, metals, glass, food, and paper industries involves the collecting, analyzing, and correlating of various instrument readings periodically by men. Results of this procedure may then be transmitted to other men in the form of instructions for manually adjusting the set points of controllers to secure optimum process conditions. But optimum operation is difficult to achieve in many processes, and control is far from continuous when based on relatively infrequent samplings of process conditions. Possibility of error is great in a *read, calculate,* and *reset* control cycle which may involve the transmission of information among several human operators. Also, time lag may be an important factor.

In contrast, introduction of digital computers into the control loop, *Fig.* 1, promises a level of automation hitherto impracticable to obtain by manual control. Appearance on the market of small, dependable computers that are designed for specific adaptation to automatic process control is making automation of this type possible. One such computer, *Fig.* 2, is a recent development of the Computer Systems Div. of Ramo-Wooldridge Corp. It employs transistors rather than less-reliable vacuum tubes, and contains printed circuit boards which can be slipped in or out of modular subunits in seconds, thus minimizing maintenance expense. Test instrumentation built into the computer expedites troubleshooting.

Specifically designed to automatically control industrial processes, the computer can be used also for pilot plant and test stand operation, for

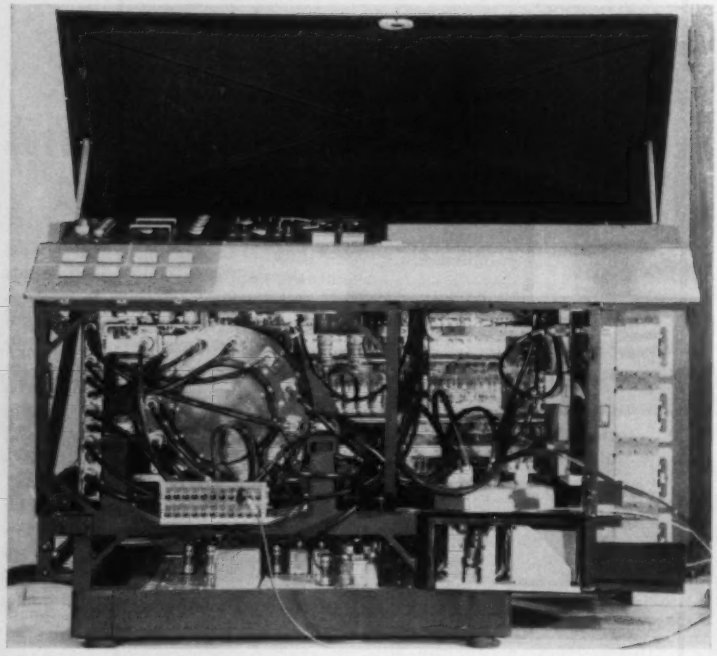


Fig. 2—This digital computer is adaptable to continuous and batch process control applications. Unit employs transistors and plug-in printed circuit boards for reliability and low maintenance. Memory drum in left foreground can handle approximately 8000 words of 17 bits plus sign, enabling several programs to be stored.

general-purpose scientific computation, and to perform the monitoring function of a data logger. When installed as a process control device, *Fig.* 3, the unit will automatically read process instruments, perform the computations necessary to relate these instrument readings to process objectives, determine the control actions that will result in the best plant operation, and activate process mechanisms or adjust set points on supervised control loops. When closed control loops are employed, the necessary feedback is obtained so that the computer can check upon the accuracy of its own operations at all times.

Process Optimization

A major advantage of computer control is the ability to operate and automatically control a process in a manner to obtain consistent desired product quality at the lowest possible cost. When, for instance, the finished product consists of several raw materials blended or reacted together, and when the incoming materials vary in both cost and composition, the computer will select a maximum amount of the low cost material and a minimum amount of the high cost material to produce a product of the desired quality level. It will automatically maintain this same selective control throughout the process, blending fractions or intermediate product components in a manner to produce the desired quality level at minimum cost. As the control actions are almost instantaneous, the required changes or variations are made with a speed of response impossible to achieve by even the most observant human operator.

In basic conception, digital computer control operates by receiving data from the various processing instruments and comparing it with process system design data stored in its memory, which may be a magnetic drum. When a variation occurs between the incoming instrument data and the system design data, the computer automatically makes control adjustments so that future instrument data will be brought into line with the programmed system design data. When mathematical computations are necessary in order to make control adjustments so that the incoming data will compare with the programmed data, the computer makes these computations before it makes the necessary control changes.

It is quite obvious, then, that the efficiency of the computer installation depends upon the completeness of the programmed data with which it is supplied. Complete program data, in turn, depend upon complete and intelligent analysis of the system to be controlled. During system analysis, factors to be considered include: 1. Limits or boundaries of the process. 2. Process objectives. 3. Process variables. 4. Equipment and operating procedures. 5. Process dynamics. 6. Instrumentation used.

With this data on hand, the system designer can establish definite control relationships which will produce the desired results and also designate the instrumentation which will measure or control the process variables. The control information may

then be programmed on the memory drum and the instruments connected to the computer. Information programmed on the drum can be compared with the instrument information 60 times each minute in a computer such as the one shown in *Fig.* 1. When an undesirable divergency occurs between the programmed information and the instrument information, the computer operates through one of its outputs in a manner to readjust the proper control and eliminate the divergency. At the same time, if it is desired, the computer will log all data on its various control functions for a predetermined period of time. Thus, permanent data may be obtained on each process run or batch, or on any desired portion of a continuous process.

Self-Checking

In addition to performing their normal control function, computers for process control can be arranged to check their own operations and check the instruments delivering the control information. Past instrument readings may be compared with current readings, and the ratios between instrument readings compared. Thus, if the information arriving from one instrument changes suddenly without compensating changes in the information arriving from other instruments, the computer can sense a malfunction and print out a warning to the operator. A computer so arranged can also continually check its own operation against the information programmed on the memory drum, and in the event of computer malfunction, print out a warning to the operator.

Practically all types of instrumentation may be used to supply control information to process control computers. Included are mass spectrometers, infrared analyzers, x-ray and ultraviolet spectrophotometers, and vapor phase chromatographs. When mathematical calculations are required to interpret the readings from these instruments, the computer does the job. Other instruments may provide information relative to chemical composition, refractive index, dielectric constant, water content, pH, and other material properties. In all cases, the information being received is reduced to numerical data and then compared with the numerical data stored on the memory drum.

While most computers for process control are designed with on-line control as the main objective, they may also incorporate a great deal of flexibility. As a stored program digital computer, it is only necessary to make changes in the program to: 1. Modify and improve control actions as indicated by operating experience or as more input instruments become available. 2. Change the controlling action from one process to another. 3. Change from data logging to fully automatic, on-line control. 4. Change between control operation, data logging, and scientific and engineering computations. In specific installations, and dependent upon the magnitude of the control operations required, a single computer installation could be adapted to control several unrelated processes at one time. Standard typewriter and punched paper tape input and output may be provided.

In summary, when used as an automatic on-line control, process control computers can automatically read process instruments, perform the computations necessary to relate these readings to process objectives, determine the control actions that will result in optimum plant operation, and activate process mechanisms or adjust set points on supervised control loops. To accomplish this, the

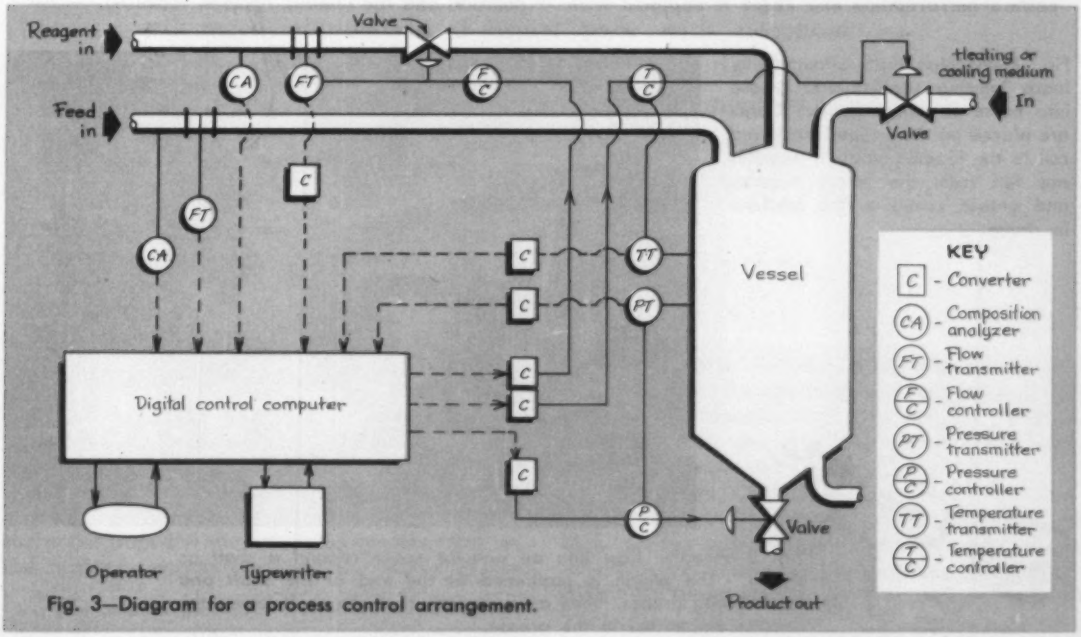


Fig. 3—Diagram for a process control arrangement.

following functions are carried out: 1. Conversion into digital form of signals from the measuring devices. 2. Input data interpretation (scaling, linearizing, compensation for interferences). 3. Computing (maximizing, minimizing, averaging, correlating, smoothing, equation solving, interpolation, extrapolation, integration). 4. Logic operations (startup, shutdown, comparison with standard conditions, selection of material flow path). 5. Checking and alarm operations (instrument checks, process stability checks, computer self-checks). 6. Data recording (process operation instructions, data logging).

Economics

During the development of their process control computer, Ramo-Wooldridge engineers carried out studies of the application of digital control systems to the actual manufacturing processes of several companies. Economic analyses of the operation of specific control systems using the computer have shown that their application to existing plants can produce tangible benefits that will return the investment in the control system within 6 months to 2 years. These benefits accrue through: Increased throughput and yield without plant expansion; improved and more uniform quality of output product; and reduction in operating costs. Many less tangible but equally beneficial advantages were noted but not included in the cost amortization calculations.

In processes where fully automatic control is not being considered for immediate installation, requirements may exist for data logging and handling equipment that can record process instrument readings and perform the calculations required to convert them into operator instructions. Secondary uses for a process control computer may also include engineering and research computations, statistical analyses, and material and energy balances. Its automatic process control capabilities could then be exploited when the need arises.

Speedup For Bearing Assembly

BEARING NEEDLES are automatically positioned in greased bores of pinion gears at Chrysler Corp.'s Kokomo plant. Insertion of grease helps hold the bearing needles in the bore of the pinion so that all parts are in position when the pinion is assembled over its shaft.

The machine performing the operations, *Fig.* 1, was built by Rehnberg-Jacobson. It receives pinions on the inclined track; bearing needles are fed from the rotary feeder; and grease is pumped directly from a drum. Approximately 1000 pinions are loaded with grease and needles per hour. A single operator oversees the machine's performance and keeps it supplied with needles, gears and grease.

Needles flow down a tube from the feeder into an annular space surrounding a stepped shaft, *Fig.* 2. At the same time, a pinion is fed into position at the end of that shaft and a measured amount of grease is pumped into the bore of the pinion. When the stepped shaft is advanced axially, the needles are pushed into the pinion bore where they remain embedded in the grease when the shaft is retracted.

The loaded pinion, with grease and needles in place, is released and rolls down a chute to the next operation. The next pinion then falls into position and the loading cycle is repeated.

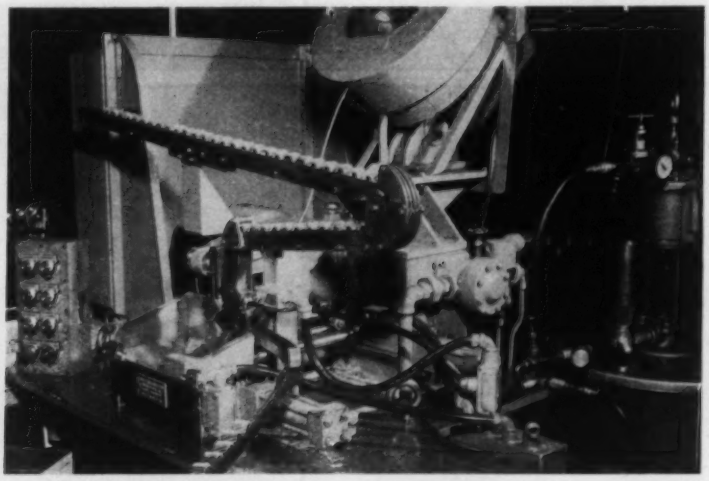


Fig. 1—Machine that automatically loads bearing needles and grease into bores of pinion gears. Gears are placed on the inclined track and roll to the loading position; needles are fed from the rotary hopper; and grease comes to the machine in drums.

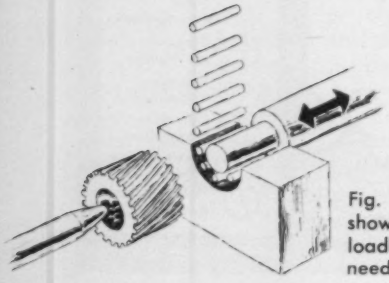


Fig. 2—Needles flow into an annular space around a shaft as shown. The pinion is positioned at the end of the shaft and loaded with grease; then axial movement of the shaft leaves the needles embedded in the grease.

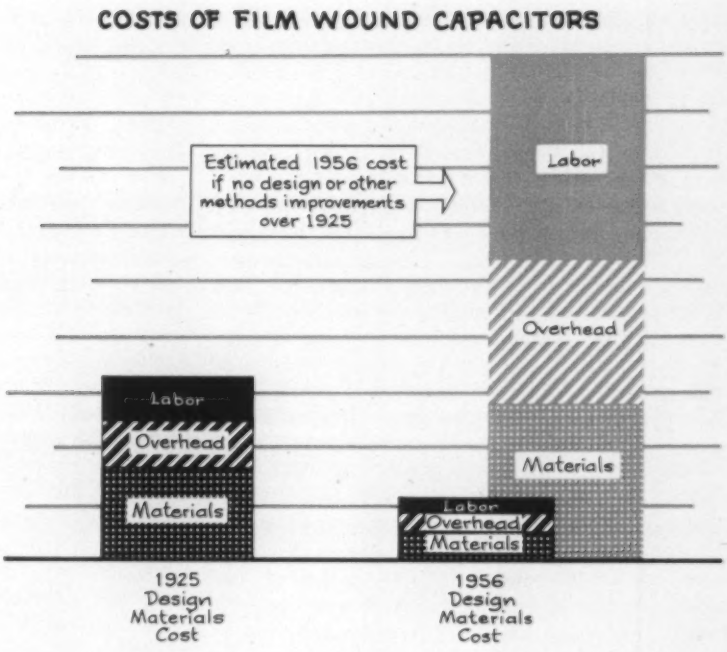


Fig. 1 — Continuing product redesign and manufacturing developments over three decades have cut costs of film wound capacitors despite interim rise in costs of labor, overhead and materials.

DEVELOPMENTS IN

AUTOMATIC PRODUCTION OF TELEPHONE APPARATUS

The dial telephone system is an ideal example of early yet advanced automation. Keeping pace with telephone apparatus design progress has been the task of the manufacturing engineer in providing automatic equipment to convert blueprints to hardware. Here are some examples of past, present and proposed developments in this field.

By **CHESTER A. PURDY**, Supt. of Development Engineering, Western Electric Co., Hawthorne, Ill.

AUTOMATION is essentially an undefined word or, more accurately, a too frequently defined one. Perhaps, then, it is just as well if we essay no new definition here. For surely the continuing competition among definitions indicates not only the intensity of current interest in automation, but the variety of its character from industry to industry depending on the problems encountered and the status of the contributing arts. It should be noted at the outset, then, that the application of automatic facilities to the manufacture of telephone products poses problems special to our industry but holds a special promise, too.

The Western Electric Co. has long emphasized the importance of automatic facilities to economical high quality manufacture. Indeed, many of the automatic sequences it has employed for years constitute forms of what we now call automation. The process of insulating cable conductors with

Based on an article published in *The Western Electric Engineer*, January 1957.

paper pulp is one example. So, too, is the manufacture of electroformed conductors for drop wire as well as the succeeding operations by which elastomer insulation is compounded and applied to drop wire. More recent examples are the automatic lines for spring assemblies in wire spring relay manufacture and the automatic machines which assemble and test dry reed switches.

Predating all of these are automatic machines used to test capacitor units. These machines perform a number of measurements, store the data in relay registers and release the stored data to cause machine actions which reject and classify defective products and place the good products in cells according to their capacitance distribution. The operation of these machines fulfills the requirements of the most stringent definition of automation today. They were installed in 1930.

Thus, for some years the use of automatic facilities has played an important role in the striking cost reductions and quality improvements that have characterized manufacture. A review of the record—extending back 10 years, 30 years or even further—discloses gratifying trends and demonstrates continuing advances in the economy and efficiency of manufacture for the Bell System. These accomplishments, of course, are a composite of many contributing factors both engineering and nonengineering. They include the effects of management concern for long term results. They reflect teamwork and the contributing skills of thousands of employees. And they represent the combined efforts of scientists and engineers to provide the best in product design and in manufacturing methods. To these various contributions we cannot assign definite weighting factors. However, it is clear that, among engineering contributions, no single element has exerted so strong an influence as the development and use of automatic facilities and the introduction of product design suitable for manufacture by automatic means.

A review of results shows the powerful nature of the influences at work. The notable advance in manufacturing output per production worker is striking evidence of the impact of engineering effort. The ceaseless striving to improve manufacturing methods, to equip new plants with the most modern facilities available and to substitute new and improved raw materials for traditional materials has dramatically advanced the efficiency of manufacturing operations. This improved efficiency—more than counterbalancing the inflationary influences of rising raw material and labor costs of the same period—has been reflected in lower prices to the customer.

It is true that productivity is influenced by other factors not directly related to manufacturing engineering—changes in volume and activity of manufacture, changes in product design, changes in product mix, etc. But it is also true that progress in manufacture significantly influences these other factors as well. Certainly progress in manufacturing methods, yielding lower prices, directly influences demand. And certainly, too, progress in manufacturing methods directly influences product design.

▶ Joining Forces

Within the engineering field the tempo of change in manufacturing methods—the drive for low cost and high quality in manufacture—increasingly depends on an intimate union of product design and manufacturing engineering thinking. Only thus may the product designer fully visualize how his designs may be framed in terms of today's most desirable processes and of the full potential of those processes. Only thus may the manufacturing engineer fully visualize those adaptations of form, materials and design requirements that will best suit tomorrow's products for economical high quality manufacture. This concept of modern manufacture is translated into action through the

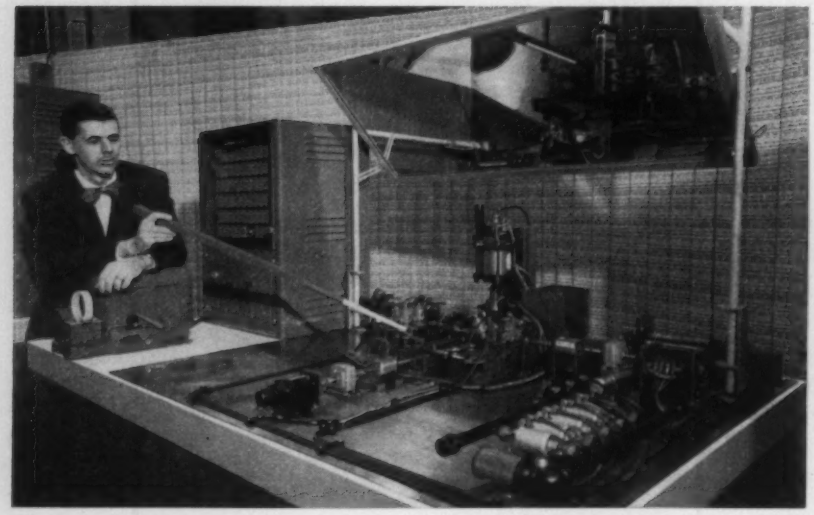


Fig. 2—Punched tape programed, two-axis positioning machine automatically locates any one of 7200 coordinates in 18 square inch area.

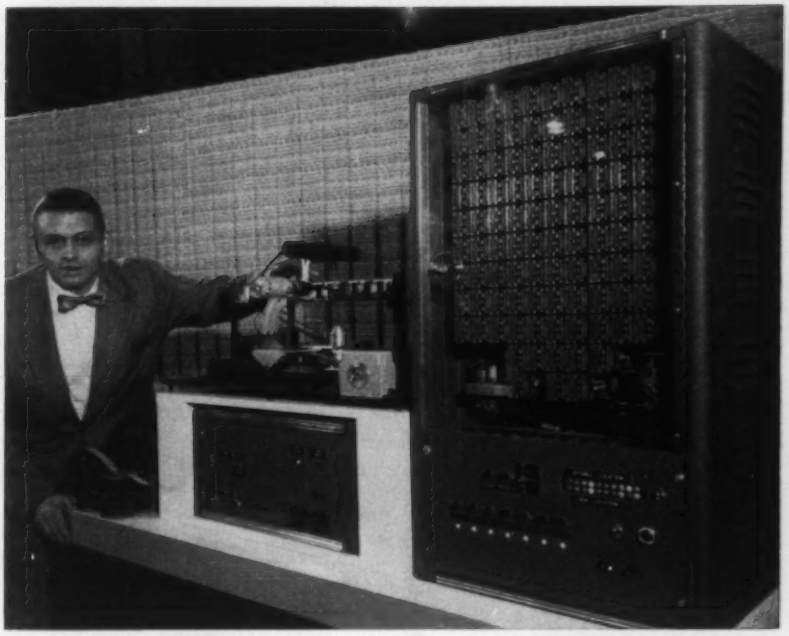


Fig. 3—Experimental terminal locating and positioning device finds and memorizes terminal locations for wire spring relays and guides wire wrapping tool into position.

increasingly closer teamwork of Bell Telephone Laboratories' product development engineers and of Western Electric's manufacturing engineers.

It is not practical in this space to undertake a detailed discussion of the combined influence of development work in product design and in manufacturing methods. Perhaps, however, a review of results in one product area will serve for illustration, underlining at the same time the long term continuing nature of such development programs. Over a three-decade period, a continuing series of interrelated product design and manufacturing developments have steadily reduced the cost of functionally similar film wound capacitors, *Fig.* 1. This continuing technical effort has been dramatically indicated in striking cost reductions. If, in the absence of that effort, the rising trends in costs of materials, labor and overhead had been allowed to prevail, the 1956 cost would have greatly exceeded the 1925 cost. Actually, the 1956 cost is less than one-third of the 1925 cost. A historical record of this sort presents a clear challenge to the engineer surveying his assigned field for possible means, not just to extend, but to accelerate the curve of progress by the application of automation.

Most favorable for automatic manufacture are highly repetitive operations of which there are a good many. For example, in a high production year, like the one just past, Western Electric produces 47 million miles of wire, all types for all purposes; makes about 2½ billion connections between wires and terminals; and welds contacts on about 2 billion springs. But even large-running basic items like these show great complexity and variety. When basic parts are combined in a piece of apparatus, the complexity and variety are greatly expanded. When apparatus codes are combined and interwired, the complexity and variety are again expanded immeasurably. This variety and complexity add greatly to the problems of automatic manufacture. So formidable are these problems that is should occasion no surprise that there is nothing now in sight to indicate that all manufacture can be made automatic on a practical basis. Indeed, the tempo of development must be greatly increased if we are barely to meet the problems of labor supply in this period of sharply rising production.

Obviously, decisions to undertake automation development in a given area are governed by the same principles underlying all manufacturing development programs: automatic facilities are used only where cost or quality considerations justify them. In addition to the inherent complexities outlined above, here are some considerations—many unique to the industry—which Western Electric engineers must take into account in applying the principles of automation to production: (1) the wide variations in apparatus and equipment content from order to order—the "tailor-made" character of most orders; (2) the use of many specialized components which require distinctive processing and hence separate manufacturing treatment; (3) the strong trend toward miniaturization and close spacings; (4) the simultaneous production of both large and small requirement items; (5) the need to manufacture both new and old product designs; (6) the possibilities of design obsolescence; (7) the possibilities of radical developments in manufacturing techniques; (8) differences in practical speeds of manufactur-

ing processes; (9) the extent of investment required by automatic facilities; (10) the effect of automaticity on merchandise investment; (11) the effect of automaticity on product shrinkage or wasteage; (12) the desirability, frequently, of closer performance limits, if these be economically obtainable; and (13) the need for flexibility and economy in testing, repair and operation of the product under conditions of customer use.

Consideration of these factors is necessary to a sound engineering approach in each instance, and will lead to a wide variety of specific answers. In particular, many of these considerations put limits on the extent of the sequences of manufacturing operations which may be automatically handled by unit groupings of manufacturing machinery. But progress in automation is measured in small increments as well as large. Effective automation is not exclusive to large integrated processes which cover all the operations from raw material to packaged product. Shorter sequences, embodied perhaps in a single machine, can achieve significant results. The highly automatic machine for assembling and testing dry reed switches, for example, accepts parts that are separately manufactured; and the switches themselves are subsequently assembled into relays, which in turn are assembled into equipment.

Automation thus involves a wide variety of techniques and mechanisms, only some of which may be used in an individual case. Combining several operations, simultaneous or sequential, in a single machine is a familiar type of mechanization. Automatic arrangements for feeding workpieces into machines, as from a hopper, and subsequently removing them automatically, are also well known. Related to these are conveyor and routing systems for both manual and mechanized operations. Recent publications have emphasized multistation machines in which work is successively transferred to, and positioned in, a number of unlike machines. Similarly, the movement of parts through successive chemical solutions, or through cycles of furnace operations, is well developed. Automatic testing equipment which sorts good product from bad has become common. Machines which include automatic adjustments for tool wear have been described.

Development Program

But to meet the present and foreseen needs of manufacture, newer and generally less understood devices, machines and systems must be readied for application to our varied and complex yet specific problems. A program of development directed to this end is being pursued and already considerable progress can be reported. It is a program directed not so much toward development of specific automatic machines or methods fully ready for use in the factory as it is toward establishing a comprehensive set of working principles, methods of approach and proofs of fundamentals. Its aim is to provide the manufacturing engineers with certain developmental tools which may in the long run enable them to synthesize this vast complex system of manufacture into one in which a large proportion of products are manufactured on automatic machines and integrated automatic lines.

It is not within the scope of this article to describe these developments in detail. Here we attempt only a brief outline of a few typical developments, together with some observations as to how they may advance the broad objective. In many kinds of manufacture these are the questions confronting the development engineer: How may one best bring the work to the tool or other processing means?—or bring the tool to the work? How may one do this automatically, accurately and for a sequence of operations? How may one best do this under the direction of stored information? Only when such basic problems in processing of work in manufacture have been analyzed in a fundamental manner may an overall system or machine arrangement be devised which can be considered efficient for the application at hand. Seeking basic solutions to these basic questions, Western Electric automation engineers have studied and developed working models of fast and versatile means for guiding work or tools to desired positions under the direction of stored information, *Fig.* 2. As a result of this investigation, the basic means for handling light loads and also heavy loads are available.

A more specific development relates to the highly repetitive and exacting operation of making connections between wires and terminals. The highly complex wiring patterns and the outstanding reliability requirements make wiring jobs among the more difficult from the standpoint of operator procurement, training and placement. If wiring could be perfectly done, great areas of inspection and repair could be eliminated. For these reasons, automatic wiring has been an item of strong desire for a long time. In certain cases and comparatively recently, the use of solderless wrapped connections has eased the problem of making connections manually. However, no satisfactory truly automatic means has been found to apply solderless wrapped connections to apparatus presently in manufacture.

Two difficult problems stand in the way. First, for straightforward automatic methods, terminals need to be accurately positioned so that wiring tools may locate them. But, to take as an example the wire spring relay, the terminals are long, flexible and considerably offset from their anchor points. These features, suitable for manual operations, cause terminals to deviate from their nominal positions with a high chance that a tool automatically directed will miss. Second, terminals may be only far enough apart to permit the use of a hand wrapping tool. Since an automatic wrapping tool must embody means for gripping a wire, transporting it and stripping it, it necessarily occupies more space than a hand tool, thus creating difficult space limitations among terminals.

To the engineers studying the first of these problems, two avenues were possible. Extensive

redesign of product might be undertaken to provide rigid terminals and to hold them in exact position on their mounting plates. This is not a simple problem. Or, working within the limitations of the present design, a machine might be developed that would take its general directions with respect to the wiring pattern from stored information, and, further, would detect and memorize the location of terminals, subsequently using this information to modify its general directions to carry the tool precisely to the actual terminal position. Such a machine has been developed, *Fig.* 3, and used experimentally. With regard to the second problem, that of space congestion, it is presently expected that certain developments in electrically joining wires to terminals (as opposed to soldering or wrapping) will overcome this problem, *Fig.* 4.

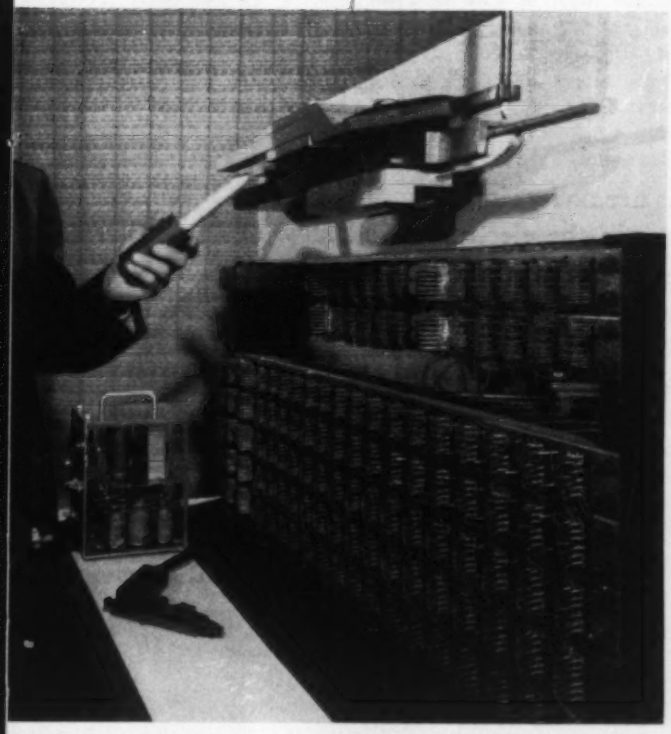


Fig. 4—Low-voltage percussive welding of connecting wires to terminals is under study as alternate for soldering and wire wrapping.

It is pertinent to an understanding of basic approaches to automation to note that the search for alternate means of automatically affixing wires to terminals has resulted from a basic analytical study of the requirements of the manufacturing operations involved. Automatic machines and processes can be successfully developed only in terms of the universe or system prescribe both by apparatus designs and process requirements. In automation development the "systems approach" is essential.

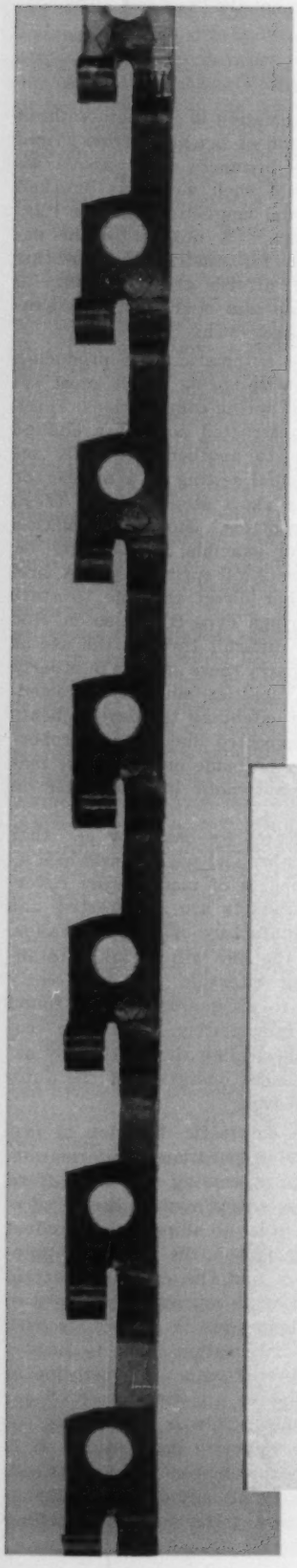
▶ Numerical Control

No discussion of automation is complete without reference to the direction of machines from stored information. In the instances cited above we have implied the use of such media as punched cards, punched tapes and magnetic tapes for relatively long-time storage. A number of the developmental devices thus far constructed utilize this method of control. It affords great flexibility in machine and tool setup and operation. It provides, in fact, for machine setting.

For illustration, the automatic lines producing spring assemblies for wire spring relays must accommodate a variety of spring combinations. These lines are presently constructed so that a change from one combination to another is quickly accomplished by the manual setting of a number of switches. But it is a short step to equip these lines with automatic controls. Stored information might direct a line, for example, at 9:30 a.m. on Monday to manufacture 2,950 springs Type A, and then at 11 a.m. further direct the line to start manufacturing 250 springs Type B, and so on. Nor would it seem unduly difficult through the use of stored information to carry these springs in orderly fashion to assembly facilities similarly directed. Thus, by utilizing and extending the developments now under way, it is expected that a large proportion of production can be made on automatic machines and integrated automatic lines operated on this general basis.

Looking to the future, we can now see that when piece part, assembly and wiring machines as well as complete sequences of manufacture covering other types of products are so directed, the entire pattern of manufacture may well change. Inventories all along the line will shrink substantially. Manufacturing intervals will be greatly reduced. Any trend to off-quality will be found and checked almost immediately. Here are economic advantages transcending those normally associated with the efficient operation of the automatic machines themselves.

Complementing the automatic direction of machines is the automatic preparation of information. Modern electronic data processing may well afford a way to integrate our entire manufacturing service—from customer's order to shipment of product and, of course, billing. Thus, the automatic preparation of information and the rapid application of this information through machines developed to operate and adjust themselves in accordance with it—even to feeding information back to master stations to be incorporated with the generation of new information—must be a definite part of our developmental thinking. This is speculation, of course, but it is not visionary speculation. It is based on an extension of principles well understood, of machines and methods already developed. Bringing them to fulfillment is today's most compelling engineering challenge.



ELECTRICAL ASSEMBLY BY RESISTANCE WELDING

Connections are no less important in electrical manufacture than in the electronics industry, and parallels in method and approach are evident. However, the requirement of mechanical strength for the more rugged electrical joint presents a fertile field for stake-and-weld assembly.

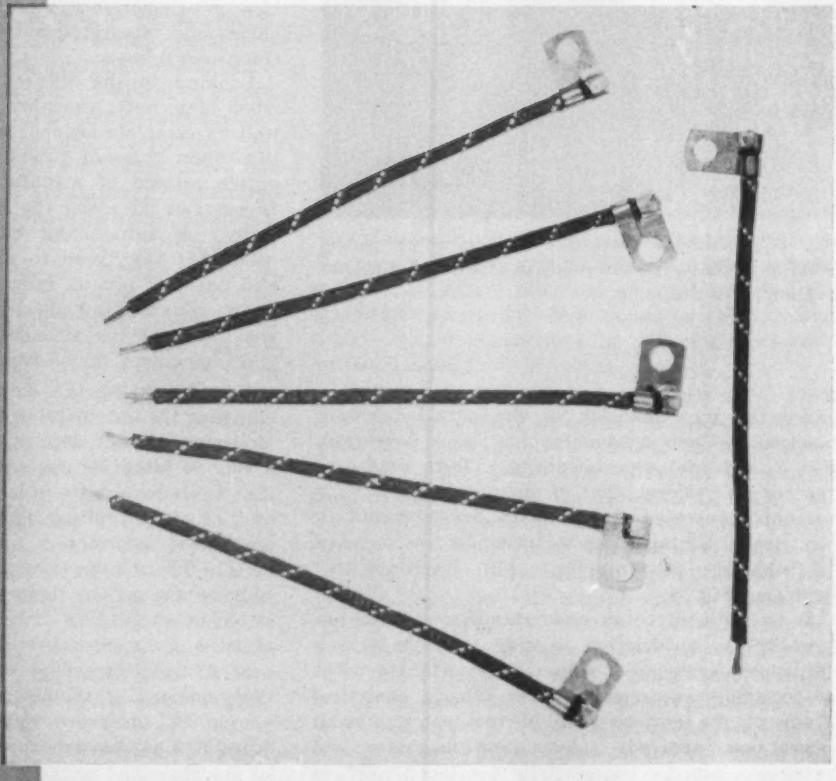


Fig. 1—Strip terminals and welded wire assemblies. These pieces are shown being assembled in *Fig.* 3.

ELECTRICAL CONTROLS in recent years have become increasingly complex and increasingly common. Aircraft, automotive and appliance industries are using great quantities of mass produced wiring harnesses and electrical control components. Because of this large production volume, automatic machinery can easily be justified by improved quality and higher productivity.

Electrical contacts must be joined to their backing strips and wire conductors must be attached to terminals and to the components themselves. These items frequently use insulating materials which are temperature-sensitive to the point where soldering techniques are not permissible. Wide and varied background of manufacturing experience, engineering knowhow and field performance are basic requirements in supplying the electrical industry with automatic welding equipment. This article describes some of the applications of resistance welding equipment built by the Taylor-Winfield Corp. for joining electrical assemblies.

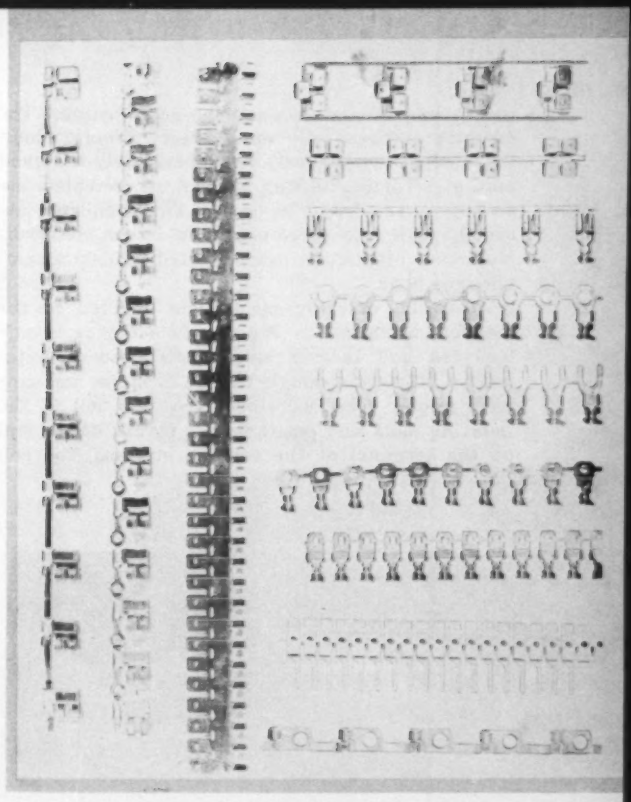


Fig. 2—Various terminals in strip form. This is a handling method in common use by several industries, particularly electronics manufacturing.

Welding Continuous Strip

An outstanding example of automation in the terminal assembly field is represented by equipment which automatically indexes continuous lengths or strips of terminals through a combination weld, stake and cutoff machine to produce terminal assemblies as shown in *Fig.* 1. A few of the various types of terminals which have been adapted to this process are shown in *Fig.* 2.

Automotive manufacturers, as well as many others in the wiring harness field, are faced with the problem of joining electrical terminals to their respective harness wires. The basic problem is to produce a good electrical joint in combination with adequate mechanical strength. Welding of the wire to the terminal is recognized as the best possible electrical joint. This method however, often produces a joint with little mechanical strength. Some manufacturers have used and are still using a straight mechanical joint with no welding. This method produces a strong mechanical joint but it often has poor or varying electrical conductivity. In order to insure a good electrical as well as mechanical joint, other manufacturers are using staking or mechanical crimping machines and following this with dip soldering. This is an excellent method, although expensive and limited to use on rubber and cloth-covered wire. On plastic-covered wire however, the heat of the solder melts the insulation near the terminal.

Use of weld, stake and cutoff machines overcomes all of these objections. The operator manually feeds wire lengths as the machine feeds a coil of terminals. A typical machine consists of three major operating mechanisms—an indexing mechanism, the basic welding machine, and a stake and cutoff device. The indexing mechanism is designed so as to be adjustable to properly index all standard strip terminals. Index, weld, and cutoff tooling for a typical unit are shown in *Fig.* 3. This unit produces the assemblies shown in *Fig.* 1. The welding ram is operated by an air cylinder which is of the adjustable-stroke type. The welding force is adjustable by an air pressure regulator. A series-parallel and 8-step tap switch are mounted on the side of the welder, giving a total of 16 steps of voltage and welding heat adjustment. The stake and cutoff mechanism consists of an air-operated toggle press into which various die sets may be placed for staking and cutting the different types of terminals. The air cylinder operating the press is independent of the welding machine, permitting individual pressure adjustment for the staking operation.

Speed of operation is limited by the ability of the operator to place the ends of the bared wire on

Article based on material supplied by Taylor-Winfield Corp.

the terminals and operate the foot switch. The machine automatically welds the terminal. Simultaneously, the previously welded assembly is staked and, at a further tooling station, one complete assembly is cut from the strip. The completed assembly falls into a receptacle or onto a conveyor. Maximum production rate reported is 3500 assemblies per hour.

A special indexing mechanism adapted to the machine is shown in *Fig.* 4. This device is air-operated and indexes small coils used in automotive starters through the weld, stake and cutoff stations. The operator places the coil in the indexing slots and positions the pigtail of the coil on the terminal at the welding station. The coil is indexed along with the terminal through the stake and cutoff stations and the assembly is then ejected.

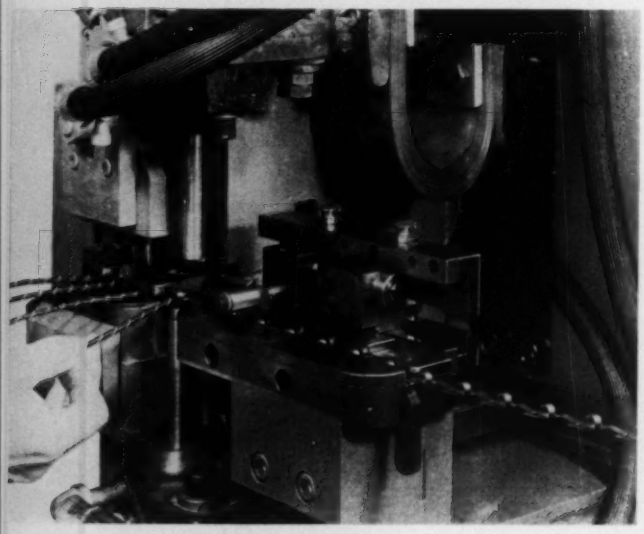


Fig. 3—Close-up view of tooling for an automatic weld, stake, and cutoff machine. Strip of terminals is fed from the right off a reel. Operator places wires on the terminals while they are still attached to the strip. Maximum production rate reported in this process is 3500 assemblies per hour.

▸ Welding Individual Terminals

Another type of weld, stake and cutoff machine is shown in *Fig.* 5. In this case a stud-type terminal is automatically handled. This small stud is welded to starter coil leads. Its hex head has a slot to receive the wire lead of the starter coil. The studs are fed from a hopper and automatically oriented. The coils are carried on an indexing device through the weld, stake and cutoff stations. Because of the random orientation of the slot in the hex head stud, a positioning device is necessary, *Fig.* 6. An air-operated escapement places the stud into its respective nest on the carrying track. No effort is made in this station to properly orient the slot. At the next station, an air-operated rotating spindle descends under light spring pressure. A small knife-like bit at the end of the spindle finds the slot and causes the stud to rotate with it until its last revolution. This action positions the slot properly.

The operator loads the starter coil into the nest of the indexing mechanism between the orientation station and the weld station. The wire lead from the coil is laid into the slot in the head of the stud. The coil and stud are indexed through the machine by an air-operated chain mechanism as shown in *Fig.* 5. In this automatic cycle the wire is first welded to the top of the hex head stud. At the next station the sides of the slot are pinched together, staking the wire to the head for mechanical strength. The final station cuts off the excess wire beyond the spot weld.

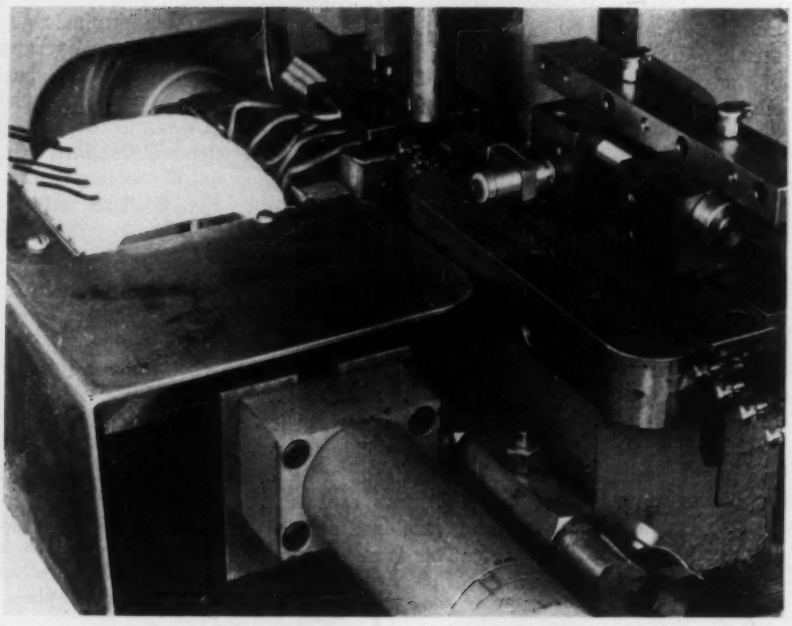


Fig. 4—Close-up of work-indexing mechanism for preassembled starter motor coils. This device is an attachment to the basic weld, stake, and cutoff machine shown in *Fig.* 3.

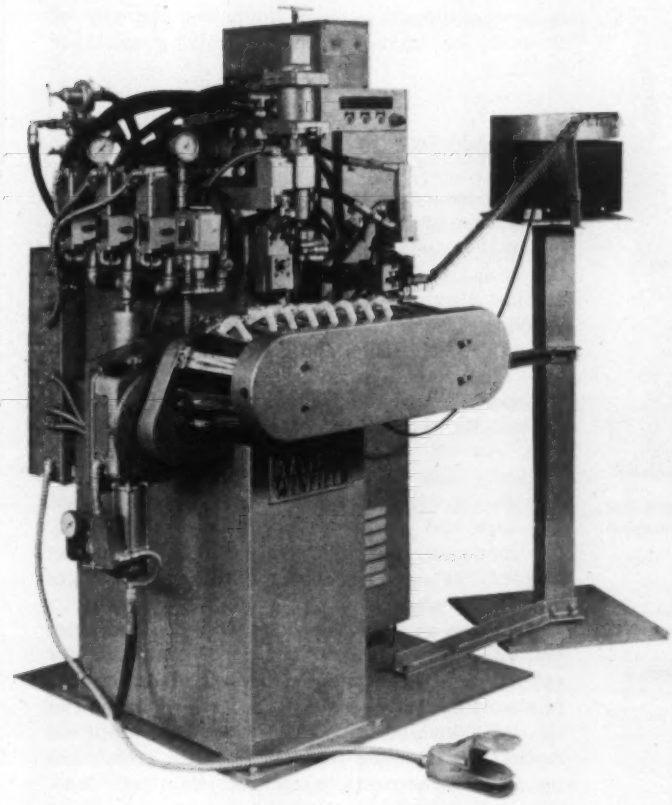
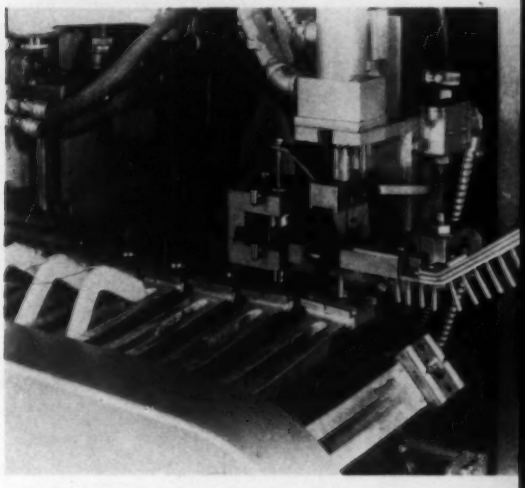


Fig. 5—Stake and weld machine with separate feeding device for individual stud-type terminals. The operator manually loads coils and places a wire end in a slot in the head of each stud.

Fig. 6—Stud orienting device. Since studs are fed from the chute of the feeder in random orientation so far as the head slot is concerned, a slot-orienting mechanism is required.



Dial Feed Welders

There are many types of terminals that can be welded on a dial feed type of machine. A fully-automatic dial feed machine has been developed for a leading manufacturer of communication equipment. A close-up of the dial arrangement is shown in *Fig.* 7. This equipment consists of a five station dial feed with a vibratory hopper that deposits two screw-type terminals in each fixture. At the next station (clockwise) is a plate feeder which lays two oblong relay components on top of these terminals. Following this is a dual checking station to insure that the parts are in proper alignment for welding. Next is the welding station and finally an air blow-off station. The terminal-feeding mechanism and vibratory bowl accommodate two different designs of terminals with a minimum of changeover time. This equipment welds two assemblies, *Fig.* 8, simultaneously, and indexes at rates to 1200 per hour, producing 2400 parts per hour. An operator merely loads bulk terminals into a vibratory hopper and plates into the unstackers.

Contact Tape Welding

Recently special contact tapes have been produced which may influence considerably the method of attaching contacts to various contact arms. These tapes often combine two or three layers of different metals to give a desired contact material with a base of weldable material. They have a number of advantages including improved product performance, easy assembly and lower cost. A wide variety of tapes are available with choice of base material and type of cladding, and which have embossments suitable for electric resistance welding.

One mechanism for shearing and welding contacts in tape form is suitable for attachment to a standard bench welder. It includes an entry guide with horizontal and vertical guiding and straightening rolls that control the position and flatness of the tape material. The tape is indexed by friction grips operated by an adjustable stroke air cylinder. The index fingers force the tape end across the shear line by the proper increment, thus controlling the length of the sheared contact. A shear cylinder operates the shear blade. Advancement of the tape moves the previously sheared contact into the corner recess of a transfer blade. The transfer mechanism then brings the contact into position over the lower electrode for the welding operation. Many variations are possible with this basic unit. Automatic feeding of the contact arms and ejection after welding are both practical. In addition, the tape feeding mechanism can be applied to dial feed equipment or

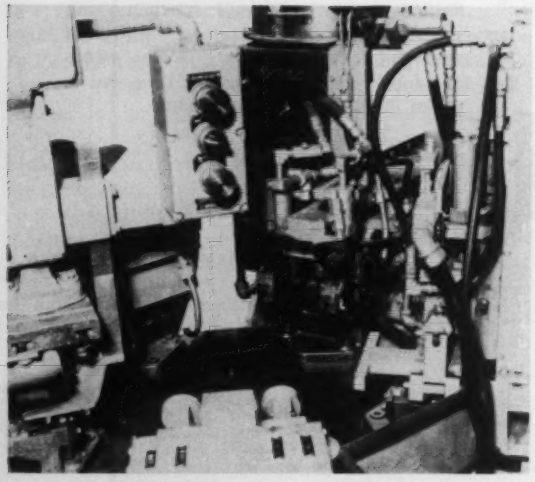


Fig. 7—Rotary indexing machine which assembles the plate and terminal stud shown in *Fig.* 8. This machine welds two assemblies at a time.

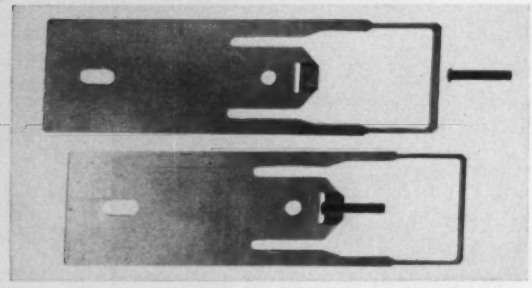


Fig. 8—Plate, terminal stud, and welded assembly. The rotary indexing machine shown in *Fig.* 7 produces 2400 of these assemblies per hour.

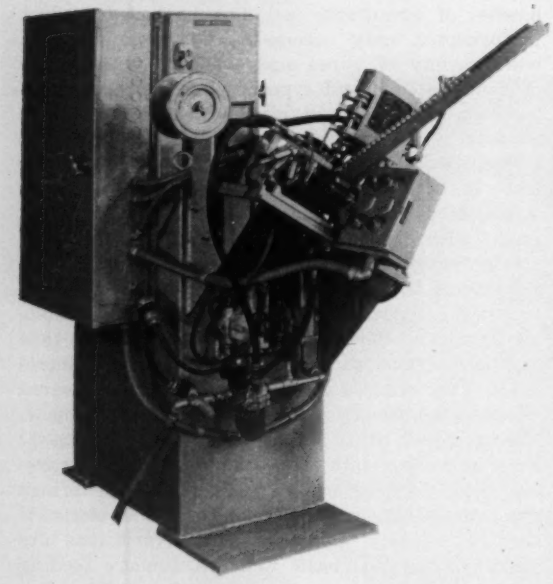


Fig. 9—Welder for joining stranded copper wire leads to battery shell. Batteries are completely assembled and activated before being fed into the welder.

in-line continuous motion equipment for any of the other mechanized processes involving resistance welding.

▶ Conductors to Battery Cases

The machine shown in *Fig.* 9 represents another illustration of the automation of resistance welding in the electrical field. Flashlight dry cells are fed from an inclined chute into an air-indexed, notched electrode which transfers them under the welding electrode, *Fig.* 10. The battery case is 0.040 inch magnesium and is filled at time of welding. The copper wire is tinned and has seven strands. Wire is fed from a spool and positioned against the side of the case. It is welded to the case, cut off, and the assembly is ejected automatically. No electrical potential which would be harmful to the battery is created by the welder. The case and anode are never short-circuited by the mechanical handling equipment. Production rates of 2500 units per hour are possible with equipment of this type.

Machines such as those described here are representative of the development of equipment for specific needs. Variations in product design and production rates required will affect the design of the individual machine, and will also dictate the mechanical handling features for most economical use in manufacturing operations. Automatic loading and unloading is often incorporated. Since the needs for each product are different, each machine has its own problems of design. Design and manufacturing experience provide the basis on which equipment is successfully developed for particular product and production needs.

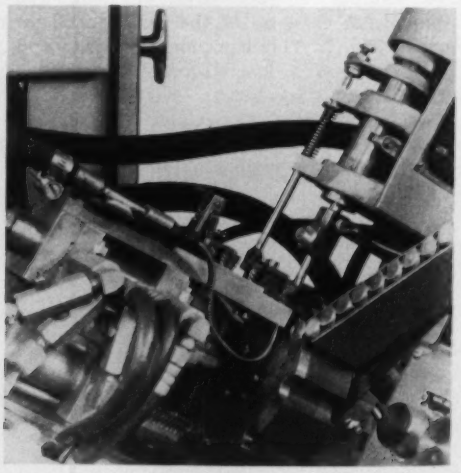


Fig. 10—Close-up of indexing device for handling dry-cell batteries. The long rod shown beside the welding head contains a shear knife at its lower end. It is actuated after the upper electrode has contacted the work. The lower electrode disc is indexed by an air-powered mechanism. The wire brush cleans each electrode saddle between index movements.

PATCH BOARD PROGRAMS SOOT BLOWERS

LARGE steam generating installations require some means for removing dust, ash, and porous slag accumulations from boiler tubes, furnace walls, and air heaters. Such deposits reduce the efficiency of the unit and may produce localized overheating and failure of the furnace elements. Small boiler installations can be cleaned manually during operation by hand lancing with steam or air. In large installations, electrically driven retractable soot blowers located in numerous parts of the boiler installation are the answer for safer operation and systematic cleaning procedures.

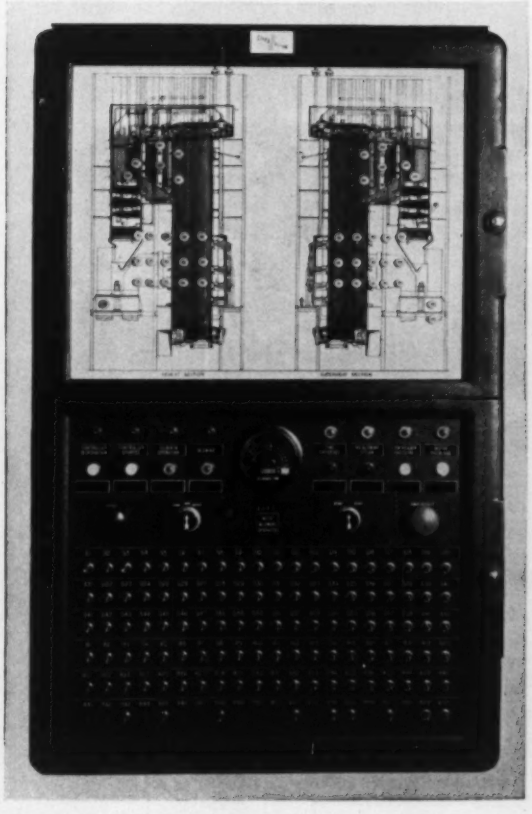
An interesting sequence controller built by Copes-Vulcan Div. of Blaw-Knox Co. to control soot blower operation is shown in *Fig.* 1. The unit is capable of controlling as many as 120 soot blowers. The heart of the controller is a rotary stepping switch which positions the control to activate the soot blowers in sequence as predetermined by patch cord connections. Programming the unit is accomplished by connecting patch cords between a jack panel for individual blowers and a similar panel for selecting the sequence of blowing.

The controller is versatile in operation since many combinations of soot blower operation may be programmed. Once a blowing sequence has been selected, operation of the blowers is completely controlled from the master panel. By use of a selector switch, the programmed sequence can be set to run automatically to completion, to recycle until stopped manually, or to cycle on a 6, 8, 12, or 24-hour blowing program.

Since certain parts of the steam generating installation require more frequent cleaning than others, each panel contains 4 jacks for each blower. This feature permits any blower to be operated up to four times in any one complete sequence. Stop jacks are also provided so that time intervals may be programmed in a sequence to allow soot blowers to be operated in groups. A button is included on the master panel to retract operating blowers to their normal positions in case of emergency.

All control, interlock, and soot blower start relays are of the plug-in type to facilitate quick testing and replacement. The control and interlock relays are mounted inside the dustproof cabinet while the start relays plug into radio tube sockets on the rear of the cabinet.

An interesting feature of the master control panel is the cross-sectional diagram of the steam generating unit with miniature lights showing the location of soot blowers. The lights are energized only when the blowers are operating. Additional information on the blowing sequence is provided by an impulse counter which records the number of sequence steps completed.



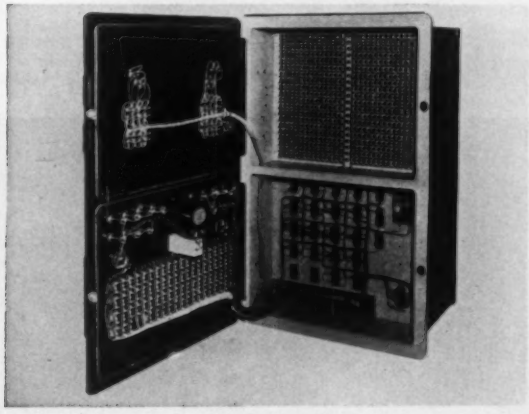
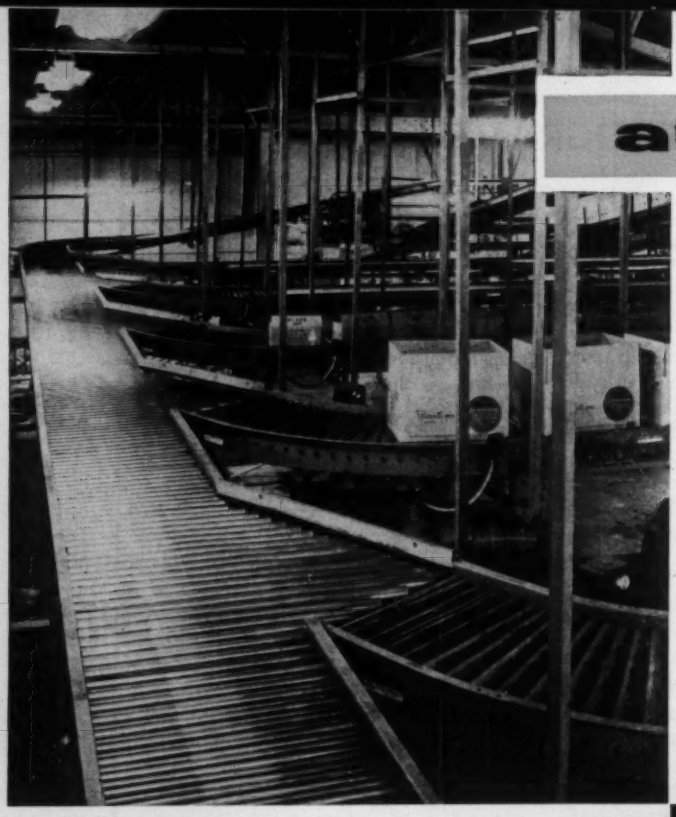


Fig. 1—Graphic view of the boiler cross-section dominates the main control panel of the controller. The location and operation of soot blowers is visually indicated on this diagram by miniature lights. Lower panel contains the sequence selector, emergency button, and control switches. When the main control panel is opened, access is gained to the patch board. Although patch cords are not shown, the blowing program is established by connections between the soot blower and the sequence jacks.

automation

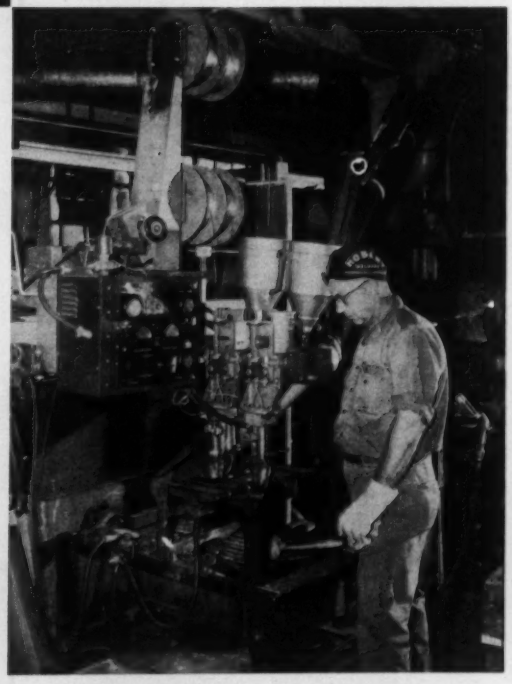


Container Conveying

MANUFACTURING and shipping operations at a glass container plant of the Armstrong Cork Co. are linked by complex system of conveyors. More than 200 conveyors have been combined to transport approximately 180,000 cartons per day from manufacturing areas through inspection-packing stations to shipping or warehouse facilities. The conveyor system is controlled by 12 control centers and 400 photoelectric devices in moving 27 different size cartons over desired paths.

Metals Joining

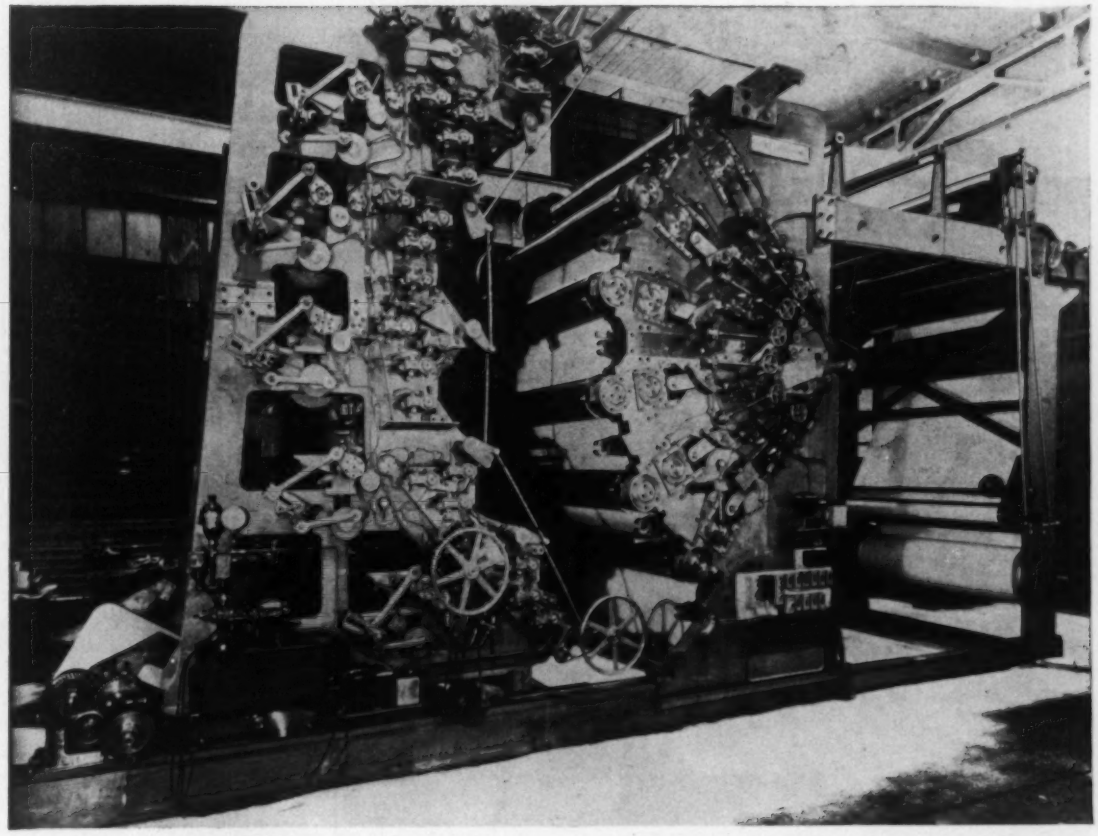
SINGLE constant-voltage source is used in this metals joining operation involving four automatic welding heads. The submerged arc process utilizes Hobart Bros. Co. equipment in welding laminated pole pieces. Multiple arcs can be operated from single constant voltage power source since welding variables of rate of travel, rate of wire feed, and arc voltage are independent of each other. This permits the establishment and operation of each arc independently. Independent controls also make the problem of setup and duplication of work much easier in this application of automatic consumable electrode welding.



Fabric Preparation

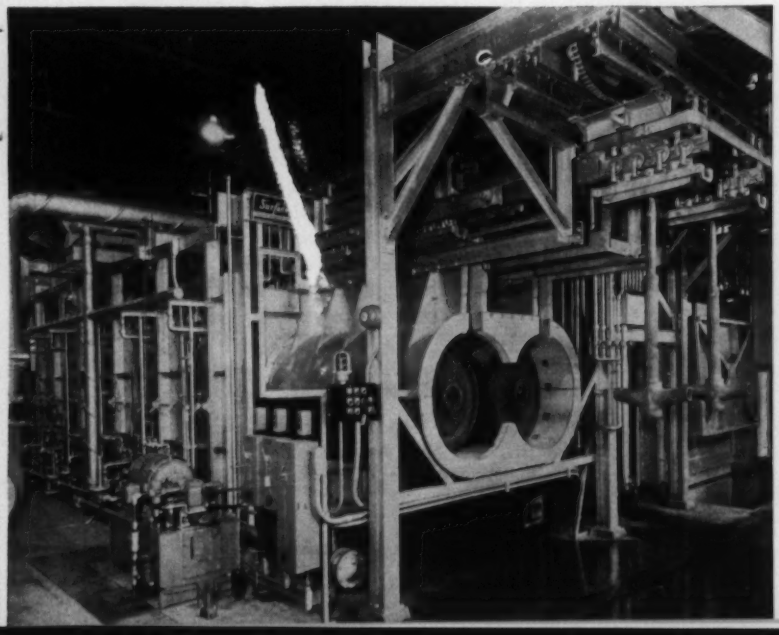
MACHINE which dries, finishes, and folds rubberized textiles has been installed by Vassar Co., Chicago foundation-wear manufacturer. The German made equipment replaces those steps in the process in which fabrics were previously hung on racks to dry, followed by hand pressing and folding. The new machine moves the fabric through special drying chambers under such control that the fabric retains its shape. Various widths and quantities can be handled through the machine at the most desirable processing rate as controlled by the operator.

In action



Special Printing Press

MASSIVE web-fed, high speed press has been built by Kidder Press Co. to print color wrapping material for food packaging industry. Up to six colors and a light coat of wax can be applied by the press. For such items as frozen food wrappings, precision register is critical for an appetizing illustration. The size and design of the press necessitated automatic lubrication of the many bearing points on the press. Bijur Lubricating Corp. equipment supplies the necessary lubrication where needed and in proper amounts that eliminate the possibility of oil spattering on the web being processed.



Heat Treatment

TWO overhead-conveyor type, continuous furnaces, side by side, produce freight car wheels at Railroad Products Div., American Brake Shoe Co. under control of one man. Special carriage, not shown, loads four wheels on hanging fixture. The fixture then passes into first of the two heat treat furnaces engineered by Surface Combustion Corp. As wheels enter furnace, special shape of furnace throat permits the wheels to act as furnace door. Automatic cycle of patented annealing treatment includes controlled pass through first furnace, specified cooling, and final pass through spheroidizing furnace after which wheels are unloaded from fixture onto carriage for transfer to cleaning and machining operations. The entire heat treating operation, including cooling between furnaces, takes place with the wheels mounted on the overhead fixture.

HYDRAULIC CONTROL OF AUTOMATIC MACHINERY—

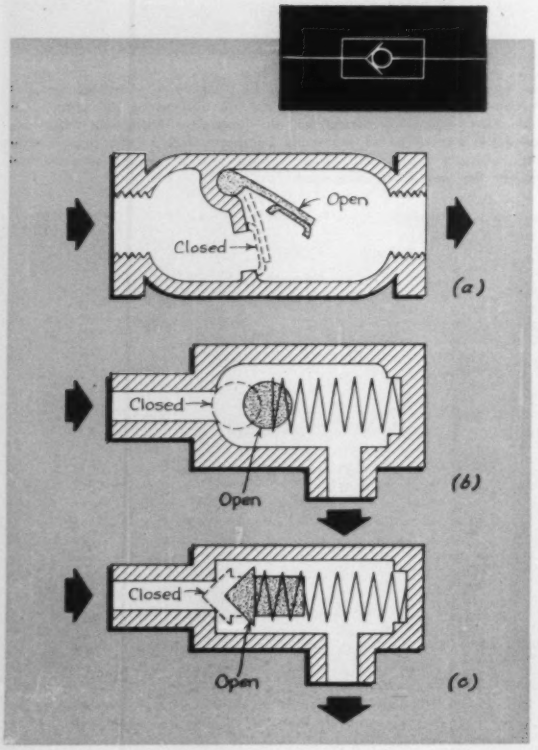
SYNTHESIS OF SYSTEMS . . . 3

AUTOMATIC ACTING AND EXTERNAL CONTROL

HYDRAULIC VALVES

This third part of a series covering the synthesis of hydraulic control systems from commercially available components describes the functioning, construction, and some of the practical applications for automatic and external control valves, and mentions features to look for in their selection.

By **R. HADEKEL**, Engineering Mgr., Sunbury Div., Sperry Gyroscope Co., Ltd., Brentford, England



HYDRAULIC VALVES may conveniently be divided into "automatic" valves and "control" valves. Automatic valves are those which respond solely to conditions of pressure or flow at the valve connections—excluding pilot connections which are not involved in the functioning of the valve beyond actuating it. Control valves are those which respond to an external control signal supplied by the operator's hand or foot, by a cam or stop on a machine, by hydraulic pressure applied to pilot connections, or electrically. Certain automatic valves also have provision for override by pressure applied to pilot connections. Pilot valves are small size control valves intended to actuate other (pilot operated) control valves.

The majority of control valves have as their function the control of the direction of motion of an actuator, usually with the facility of stopping the actuator in the midst of its travel. Valves primarily designed for this purpose are generally termed "directional control" valves. If such valves

Fig. 18—Three common types of check valve are: swing check valve *(a)*, ball check valve *(b)*, and poppet check valve *(c)*. Function of check valves is to permit flow in one direction only.

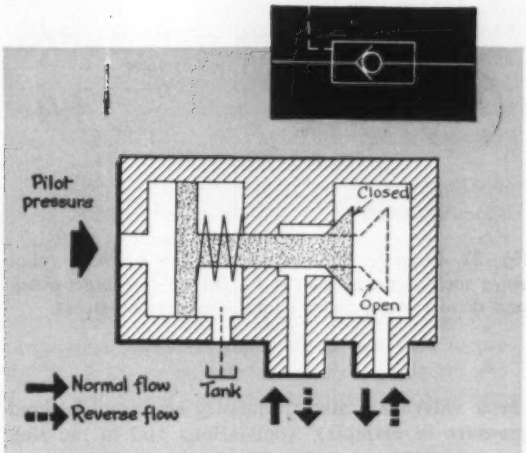


Fig. 19—Pilot piston on this poppet check valve allows disabling of the valve when desired. Pressure applied to the pilot connection opens valve to flow in both directions.

are hand or mechanically operated, it is possible to use them to exert a measure of control over the speed as well as the direction of motion of the actuator. Most directional control valves however are not designed for speed control purposes. Use of this type of valve for speed control is even more difficult as a rule when it is pilot operated, and impossible with solenoid actuation. The most important application where speed control is required is that of servo systems. Control valves specifically designed for these will be referred to as "servo" valves in opposition to "directional control" valves. Directional-plus-speed control of actuators is however frequently called for in some essentially open loop machine systems, and for such applications it may be possible to obtain stock directional control valves that have slight modifications to give more gradual opening of ports and a better measure of speed control.

Except for check valves and some relief valves, practically all hydraulic valves for industrial purposes are of the straight slide type. An exception is in the design of pilot valves which are often of the rotary slide type. The usual construction includes a hardened steel slide working either directly in a cast iron body or in a hardened steel liner fitted in the body. The latter construction is more expensive but should last longer.

Some valves carry soft seals on the slide which have to pass ports in the body or liner. These should be cheaper and free from leakage, but the author has no information on how well the seals would last under what would appear to be rather arduous operating conditions.

Automatic Acting Valves

The simplest automatic acting valve is the check or nonreturn valve, some versions of which are diagrammed in *Fig.* 18. Its function is to permit flow in one direction and to prevent reverse flow. In this respect it is analogous to the electrical half-wave rectifier. The same design objectives—zero forward resistance and infinite resistance to back-flow—hold for each.

In *Fig.* 18(*a*) is shown a cross-section of an ordinary swing-type check valve. Fluid flowing in one direction unseats the disc; when the flow is stopped or reversed the disc drops, closing the port. Check valves of this type are available with gravity or gravity-plus-spring closure. The ball check valve, *Fig.* 18(*b*), is commonly used in hydraulically-actuated automatic machines of all types. Its operation is self-evident from the diagram. Poppet-type check valves, *Fig.* 18(*c*), include a hardened steel disc which is spring-loaded against a seat. For high pressure applications the mating surfaces of the disc and seat are usually precision lapped to prevent leakage. Some poppet check valves are arranged to permit free rotation of the disc to distribute the wear.

When well made, check valves are capable of holding back-pressure without any measurable leakage. A common use for the check valve is in preventing unwanted gravity drainback of oil during shutdown or between operating cycles of hydraulic systems.

It is possible to obtain a kind of check valve that has a pilot piston of sufficient area to overcome back-pressure, *Fig.* 19. This valve operates the same

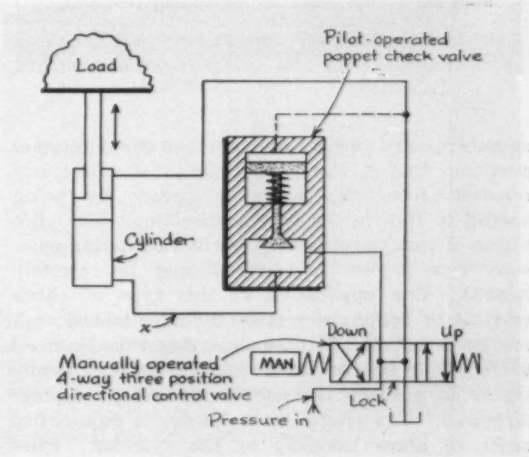


Fig. 20—Application of the pilot check valve of *Fig.* 19 to hold a vertical piston locked in any position. Pilot-release feature of check valve is required to allow lowering of the piston when the 4-way valve is shifted to its *down* position. In practice, a combined restriction and check valve would be inserted at point *x* to control rate of descent of piston and to insure availability of pressure at pilot connection of the check valve during downstroke.

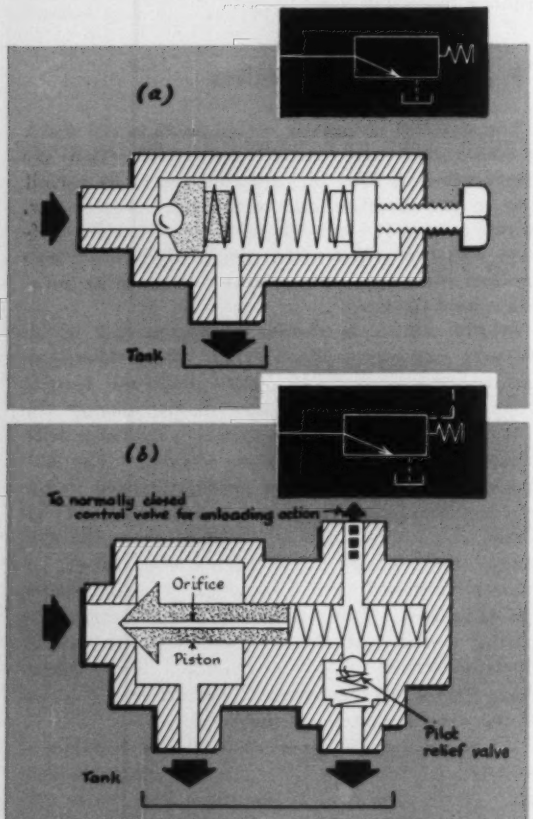


Fig. 21—Two types of relief valve. Ordinary type (a) has an adjustable spring precompression feature to set opening pressure. In (b), oil flows through orifice to back side of piston and balances this member hydrostatically. Flow is stopped by pressure of a light spring. When pilot check valve opens, release of pressure on back side of the piston opens valve quickly and smoothly. Venting connection allows use of this valve for unloading purposes.

as an ordinary check valve, but has the additional provision that it can be disabled; i.e., effectively removed from the hydraulic circuit by being opened to flow in the reverse direction. The pilot piston of this valve usually receives actuating pressure from a pilot valve which may be remotely located. One application of this type of check valve is in holding a vertical cylinder locked on a column of oil, *Fig.* 20 (the usual directional control valve, left in neutral, cannot hold a cylinder firmly locked in position because of its leakage characteristics). The pilot-release feature is required in order to allow lowering of the cylinder. Pilot

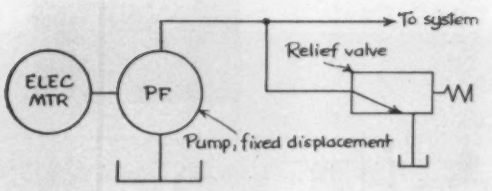


Fig. 22—Diagram illustrates use of an ordinary relief valve such as that shown in *Fig.* 21 (a) to protect pump and drive motor against excessive system pressures.

check valves are also frequently employed to hold pressure in clamping applications and in molding presses, and are useful for shutting off accumulator circuits and opening them on demand.

Relief Valves

Most hydraulic systems for powering and controlling automatic production machines require means to limit the pressure that can develop at one or more points in their circuits. The relief valve, *Fig.* 21, can perform this function by opening a port to a tank connection when pressure exceeds a preset level. When the excess pressure is relieved the valve closes again.

Simplest form of relief valve, *Fig.* 21(*a*), is in essence a check valve, but incorporates two additional refinements to adapt it for relief duty. These are, specially-calibrated springs, and means such as a screw to adjust the precompression of the spring and hence the opening pressure of the valve. Relief valves of this type are subject to chattering and pounding as pressures and velocities increase. These are caused by the inevitable hydrodynamic effects that occur at the instant of opening, and are aggravated by the heaviness of the springs required for high-pressure operation. Various modifications are sometimes applied to achieve smoother operation of this type of valve at the higher pressures. They include: Throttling the outlet opening of the valve, providing a dashpot type of seal, and utilizing differential pressure across the operating plunger or slide to allow use of a lighter spring.

A more sophisticated type of relief valve, *Fig.* 21(*b*), in effect makes use of an integral pilot relief valve to operate the main valve. Oil from the line passes through an orifice in the piston and acts on the back side of the piston to maintain it in hydrostatic balance. Slight bias from a light spring keeps the valve closed. When pressure reaches a sufficient intensity the pilot relief valve opens. Because the piston was in hydrostatic balance, the slightest relief of pressure on its back side causes piston movement in a direction to open the valve. Relief valves of this type have excellent operating characteristics; they remain closed right up to their pressure settings then quickly relieve the full volume for which they are rated. Some

models, such as the one diagrammed in *Fig.* 21 (*b*), incorporate an extra connection by means of which the cavity behind the piston may be vented to tank through an external control valve. When so vented, the relief valve will open at quite low pressure and the system can be unloaded without the necessity of providing a separate unloading valve.

If the function of the relief valve is to be protection of the pump and its drive motor, *Fig.* 22, including an unloading action, *Fig.* 23, the qualities to be looked for may just be low leakage below the operating pressure and silence in operation—accuracy being a minor consideration. In many cases, however, relief valves are used to control the force to be exerted, as by a cylinder, *Fig.* 24, and additional qualities are then desired. Among

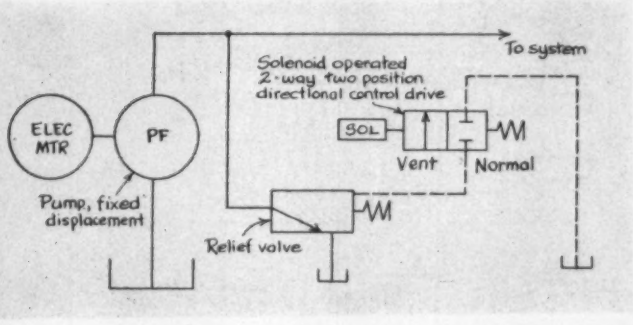


Fig. 23—Relief valve of *Fig.* 21 *(b)* is used in this circuit to operate as an ordinary relief valve and also perform the function of an unloading valve. Unloading action occurs when directional control valve is moved to *vent* position. This permits the relief valve to open and divert the flow of oil to tank.

them are: Absence of random variation in operating pressure, absence of margins between pressures on opening and closing, and low variation of pressure with flow.

▶ Reducing Valves

Reducing valves, *Fig.* 25, are used when a portion of the system is to be operated at a pressure lower than that in the supply line. Two basic types are available. One provides a constant outlet pressure regardless of supply pressure, and the other type maintains a fixed reduction in supply pressure. Design of the operating plunger distinguishes the type. The one shown in *Fig.* 25 is a constant outlet pressure type and operates as follows: Oil entering the inlet connection passes through the valve to the outlet. Some of the oil enters the orifice and acts on the back side of the plunger. When the force so developed builds up to slightly more than that of the opposing spring force, the valve will close. In this way, pressure in the outlet is limited to that determined by the spring setting.

One type of reducing valve contains an integral pilot relief valve to actuate the main valve. This arrangement resembles that for one of the relief valves previously discussed. A circuit employing a reducing valve will be described in conjunction with the discussion on sequence valves to follow.

▶ Sequence Valves

A simple type of pressure sequence valve, *Fig.* 26(*a*), is one which establishes a connection from port *A* to port *B* when pressure at *A* exceeds a certain value. The difference between this and a relief valve is simply that port *B* on the sequence valve is not necessarily a tank connection. For this reason, pressure at *A* may rise above the value at which the valve begins to open, and can be impressed on a circuit connected to *B*. Valves of this type are available with a built-in check valve to allow free flow from *B* to *A*, and also with a pilot pressure connection to open the valve remotely, *Fig.* 26 (*b*), regardless of the pressure at *A*. Other variants will be described later. *Fig.* 27 illustrates an application for a sequence valve and also a reducing valve in limiting the pressure of a clamping cylinder below that of the main cylinder in a large press.

Besides their application to automatic sequencing systems, pressure sequence valves may be used to maintain a set minimum pressure in a supply line at *A* while line *B* is connected to a service which may cause the pressure to drop to a lower intensity. For example, port *A* may be connected to the pump and a number of pilot valves, while port *B* may go to the main control valves; the sequence valve will then insure that sufficient pressure is available to the pilot valves so that they will operate the main valves.

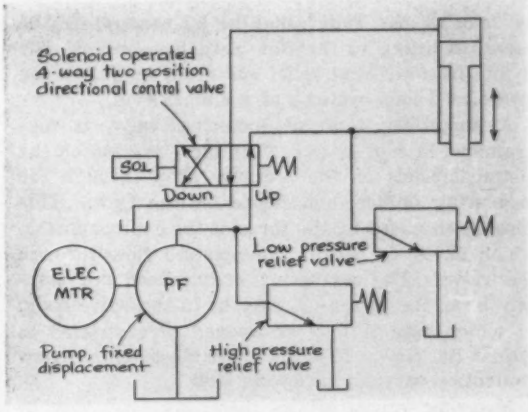


Fig. 24—In this circuit, two relief valves control the operation of a press cylinder. The high pressure relief valve controls downstroke of the cylinder and press force, while the low pressure relief valve governs upstroke. Heating of the oil during long loading cycles is reduced by this arrangement.

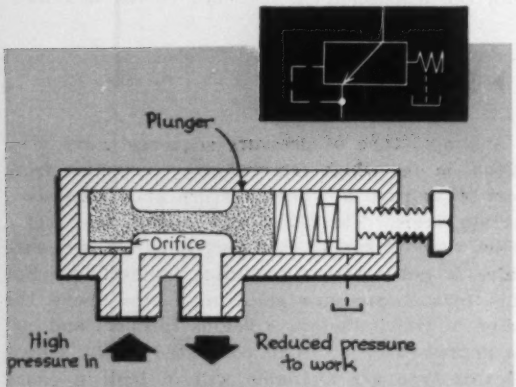


Fig. 25—Reducing valve provides constant outlet pressure regardless of input pressure. Spring precompression determines outlet pressure.

Metering Valves

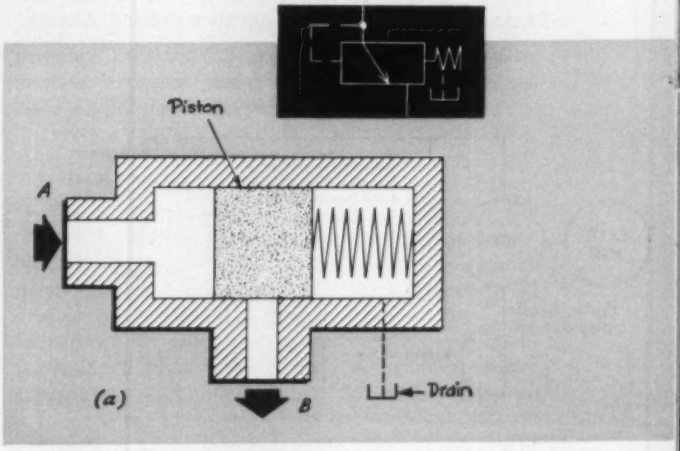
Metering valves are valves that are used to control the flow to an actuator by means other than directly governing the pump delivery. The source of supply may be a fixed delivery pump, with or without an accumulator, or even a variable delivery pump having some sort of pressure governing. The principle is that flow is controlled either by throttling or by opening a bypass path to tank. If a fixed restrictor such as a needle valve were to be used for this purpose, flow would vary considerably according to system conditions; in a metering valve, independence of load conditions is achieved by "closing the loop," that is, by controlling the valve according to the flow actually obtained. (It should be noted that relief and reducing valves are also closed loop systems of a simple kind.)

A throttling type of metering valve is diagrammed in *Fig.* 28 (*a*). The force exerted on the piston depends on the pressure drop through the measuring orifice, and hence on the flow. This force is balanced by the force of the control spring, which is set to permit the required flow through the valve. The measuring orifice need not actually be in the piston—it may be in the valve body, in which case it may be opened or restricted to adjust the flow. It is also possible to obtain flow control by varying the spring load.

Metering valves of the throttling type may be used at the inlet or outlet of a control valve or actuator, or they may be mounted in a branch line leading to tank. In the latter case the flow to the work is the difference between the metered flow to the valve and the pump delivery, and accurate control may be difficult.

A method not subject to the same difficulty is to use a bypass type of metering valve, *Fig.* 28(*b*). The advantage of bypassing a portion of the flow to tank, rather than throttling flow into or out of an actuator, is that the pressure is not raised significantly above that required to operate the actuator. Valves of the bypass metering type are also available with integral relief valves.

An application of a bypass-type metering valve to control the speed of a hydraulic motor is shown in *Fig.* 29. The designation *V*(*PC*) for this valve identifies it as having a variable orifice, *V*, and pressure compensation, (*PC*).



Qualities required in metering valves are stability and constancy of flow irrespective of load conditions. Variation of flow with changes in oil temperature should also be at a minimum. Some temperature effect will occur however, particularly at the low end of the flow range. Temperature compensation may be feasible but is not a feature of currently available metering devices.

Packaged control units for machine tools are available which include directional control valves and metering valves. They may be operated directly, through pilot valves, or by means of cams on the machine. Usually they have two metering valves that are individually adjustable. Functions controlled by these units may be: *Rapid approach, feed, rapid return,* etc.

Directional Control Valves

Directional control valves may be distinguished according to their methods of operation, number of ways or connections, and the number of positions or modes they may assume; for example, manually operated four-way, three position directional control valve (see *Fig.* 20 and 27).

Most directional control valves (excluding pilot valves) are designed for controlling double acting cylinders and accordingly have four ways or con-

nections, which we shall designate *P* (pressure), *T* (tank), *A* (cylinder), and *B* (cylinder). If a single acting cylinder is to be used, connection *B* remains unused.

Number of positions refers to the number of distinct routings the oil may undergo. There are usually three positions, of which the central one is called "neutral," for operating double acting cylinders. Two position directional valves in which neutral is omitted are also available, particularly for solenoid operation, *Fig.* 23 and 24. In other cases the omission of neutral does not appreciably simplify the valve.

Essential action of directional control valves is *A* to *P* and *B* to *T* in one end position of the valve, and *A* to *T* and *B* to *P* in the other end position. A wide variety of neutral positions is listed by manufacturers, the chief ones being: 1. *Closed center,* in which *P* is blocked. *A* and *B* may be blocked, *Fig.* 30(*a*); *A* and *B* may go to *T*, *Fig.* 30(*b*); or *A* may be blocked and *B* go to *T*, *Fig.* 30(*c*). 2. *Open center,* in which *P* is connected to *T* in neutral position of the valve. *Fig.* 31 shows some variants of open center valves. 3. *Pressure center,* or *A* and *B* to *P*, with *T* blocked, *Fig.* 32. A few other combinations are available, for example, valves in which *A* is blocked at one extreme position and *B* at the other.

The object of open center valves is to enable the pump to be unloaded when bringing the valve to the center position. If the valve is lever operated the lever should preferably be spring centered. The ordinary open center valve is however subject to the limitation that two or more actuators cannot be controlled independently because if any valve in a parallel hookup remains in a neutral position the pressure is bypassed to tank.

To escape from this limitation it is necessary to resort to closed center valves which contain two-way valve sections that are open in the center position. *Fig.* 33 shows the hookup, in which the two-way open center valve sections are placed in series to bypass the oil to tank when all the valves are in neutral. If any one of the control valves is moved away from neutral the pump by-

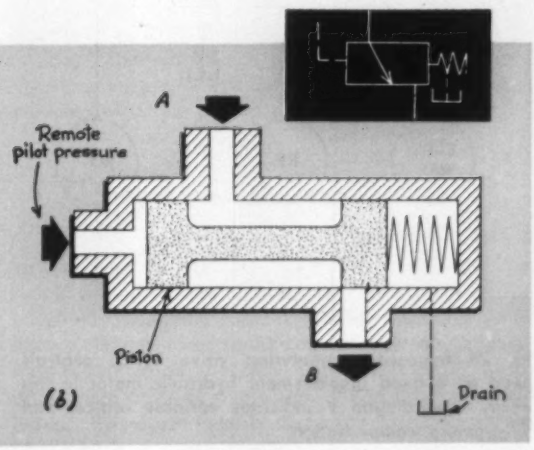


Fig. 26—Two types of sequence valve. Directly operated type *(a)* opens when inlet pressure creates a force equal to spring setting. Type *(b)* can be opened by a remote valve regardless of pressure at *A*.

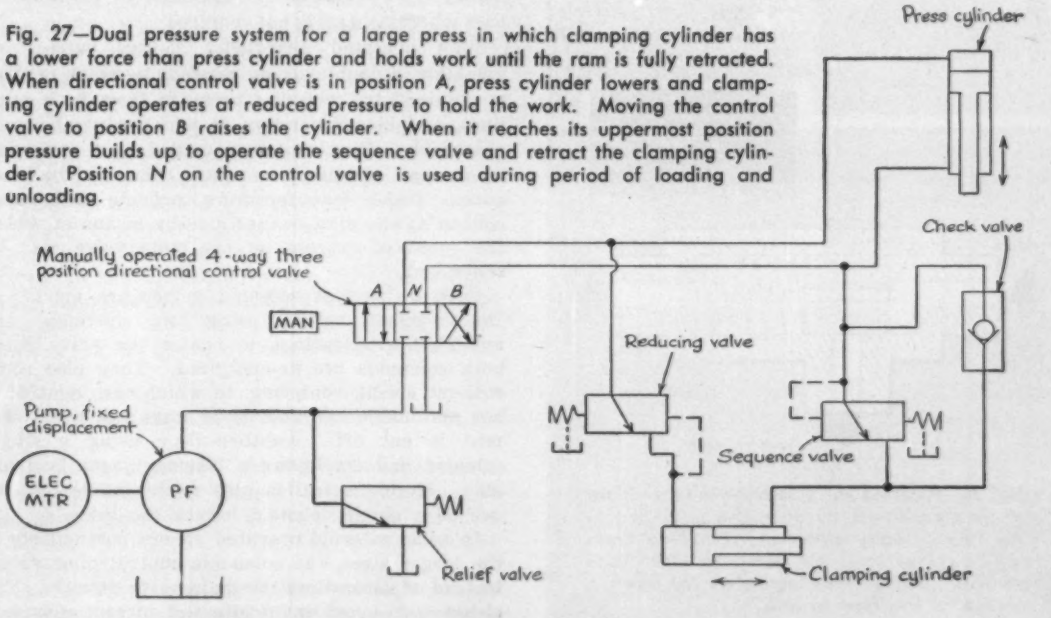


Fig. 27—Dual pressure system for a large press in which clamping cylinder has a lower force than press cylinder and holds work until the ram is fully retracted. When directional control valve is in position *A*, press cylinder lowers and clamping cylinder operates at reduced pressure to hold the work. Moving the control valve to position *B* raises the cylinder. When it reaches its uppermost position pressure builds up to operate the sequence valve and retract the clamping cylinder. Position *N* on the control valve is used during period of loading and unloading.

pass path is cut off. Provision may be made for not cutting off the bypass in the case of a valve movement leading to the return of fluid from a single-acting cylinder, which action does not require the pump to come on load. Valves of this type are available in "stacking" form, *Fig.* 34. The series connections for the bypass path are established directly from one valve to the next, without pipes, in this design. Parallel *P* and *T* connections are also provided through drillings in the valves, thus the only pipes to be connected to the "stack" are the external *A*, *B*, *P*, and *T* lines. The latter are connected to end pieces provided. One end piece may incorporate a relief valve. This kind of setup enables simple circuits of the open center type to be achieved with the maximum of compactness and the minimum of effort.

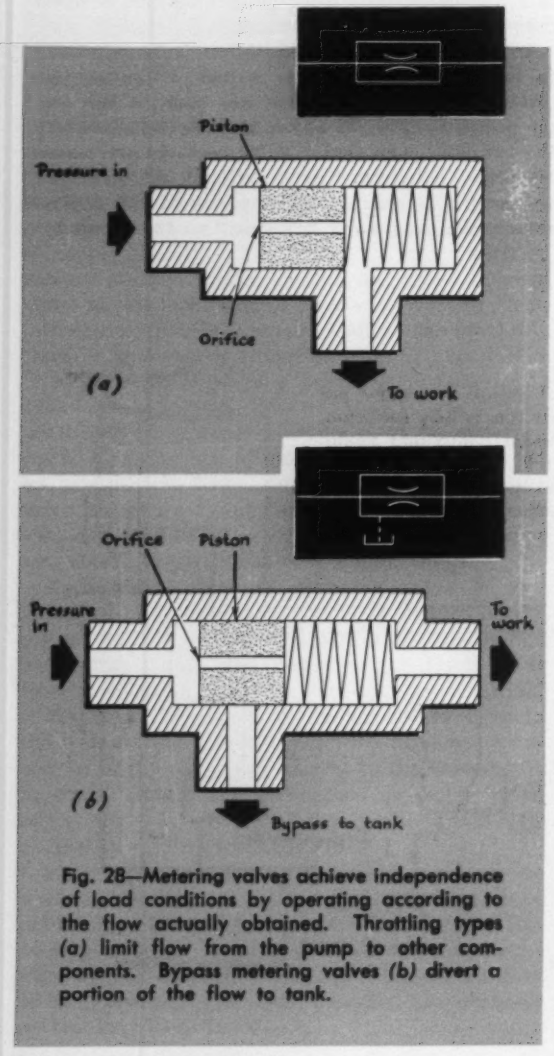


Fig. 28—Metering valves achieve independence of load conditions by operating according to the flow actually obtained. Throttling types *(a)* limit flow from the pump to other components. Bypass metering valves *(b)* divert a portion of the flow to tank.

Apart from pilot valves, which will be described separately, directional control valves are not usually intended for mechanical operation by cams or stops. The standard versions are: Manually operated by lever or pedal, pilot operated, and solenoid operated.

Manually operated valves are listed in the following variations: Detent type, in which light

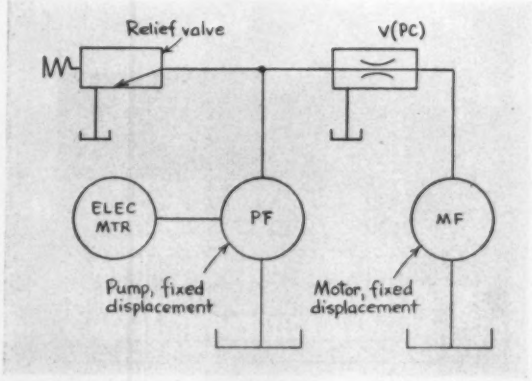


Fig. 29—Bypass-type metering valve *V(PC)* controls speed of a fixed displacement hydraulic motor in this circuit. Designation *V* indicates variable orifice, and *PC* pressure compensation.

catches hold the valve in all three positions ("stay-put" action); spring centered type, which returns to neutral on release of the lever; and spring biased type, which would normally be confined to uses where neutral is not required.

Pilot operated directional control valves are available in double acting versions in which neutral is obtained by releasing pressure from both pilot lines, and biased versions in which neutral is not obtainable. Bias may be provided by a spring or by a small piston permanently connected to pressure. Some manufacturers provide adjustable chokes at the pilot connections by means of which the speed of reversal of the main valve may be controlled.

Both dc and ac solenoid valves are marketed. Double-acting valves, using two solenoids, are available with springs to center the valve when both solenoids are de-energized. They also come without spring centering, in which case neutral is not obtainable and the valve stays put when current is cut off. Another type using a single solenoid and employing a biasing means is available. Here, neutral is also unobtainable but the use of a single solenoid lowers the price.

In some solenoid operated valves, particularly in the larger sizes, the solenoids control pilot valves instead of controlling the main valve directly. The object is to avoid undue size and current consumption since large valves require substantial operating

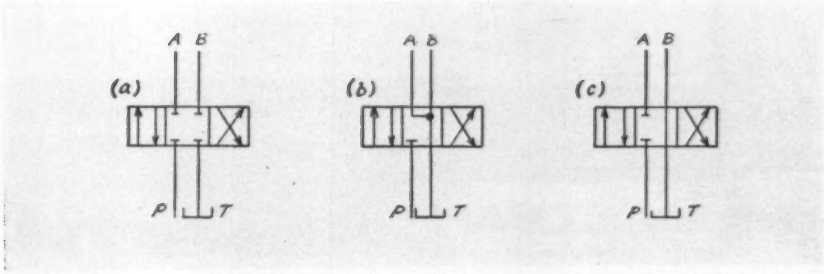


Fig. 30—Common types of closed center directional control valve include: *(a)* All ports blocked. *(b)* Cylinder ports *A* and *B* connected to tank *T*. *(c)* Cylinder port *A* blocked, cylinder port *B* connected to tank *T*. Pressure port *P* is blocked in neutral position of valve in all types shown.

forces, even though on the face of it slide valves appear to be fully balanced.

Foot operated valves are obtainable in biased versions with a single pedal and spring centered versions with two pedals.

▶ Pilot Valves

Pilot valves are essentially small size control valves (connections are typically ¼, ⅜, and ½-inch) intended for manual, cam or stop, and occasionally solenoid control. Their function is to control larger directional control valves. A common construction is rotary, with a lever adapted to either cam or hand operation. Slide types are also listed. These are usually made for direct operation of the slide by hand or cam, and are not commonly fitted with a lever as are larger control valves.

For cam operation the valves usually have "stay-put" action and two positions only, but particularly in the slide types may have spring bias action for the two positions. For manual operation three position types are available, with neutral usually of the closed center type. If the main valve to be controlled is to be able to reach neutral, the neutral required on the pilot valve will usually be of the type in which both "work" connections are to tank (*A* and *B* to *T*).

Pilot valves are also available in two and three-way types. Two-way types may provide *A* blocked or to *B*, where most often *B* is to tank. In three-way models the action may be *A* or *B* to *C* where *A*, *B*, and *C* may be arbitrary, or more frequently *A* to *P* or *T*. Where no tank connection is involved directly in the operation of the valve, a leakage return connection is frequently provided to prevent subjecting the valve seal to high pressure. This prolongs the life of the seal and reduces its friction.

▶ Miscellaneous Control Valves

Several manufacturers list two-way cam operated valves with full-size connections which may be used as sequence devices in the ordinary sense, or to unload the system at the end of a particular operation.

Pilot operated two-way valves (usually termed "sequence" or "counterbalance" valves according to particular connection combinations) are also available. These valves are made with spring or pressure bias to both closed and open positions. Leakage may then be taken to one of the main connections to tank, or to a separate leakage return line. Variants are also available which embody a check valve giving free flow in one direction. Some manufacturers list valves having two pilot connections such that pressure applied to either connection operates the valve away from the "returned" position.

Valves of the foregoing types find many applications for sequence and unloading functions, which will be dealt with in greater detail in a subsequent part of this series.

At least one manufacturer lists a prefill valve, *Fig.* 35, which may be used in presses for filling

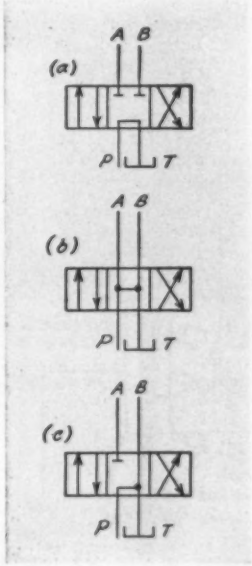


Fig. 31—Open center valve types. *(a)* Cylinder ports *A* and *B* blocked. *(b)* All ports connected to tank *T*. *(c)* Cylinder port *B* connected to tank *T*, cylinder port *A* blocked. Pressure port *P* goes to tank *T* in all cases.

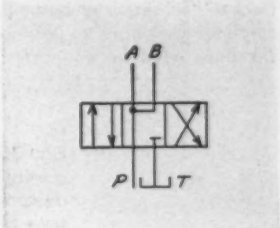


Fig. 32—Pressure center valve connects cylinder ports *A* and *B* to pressure port *P* in neutral position of valve. Tank connection *T* is blocked.

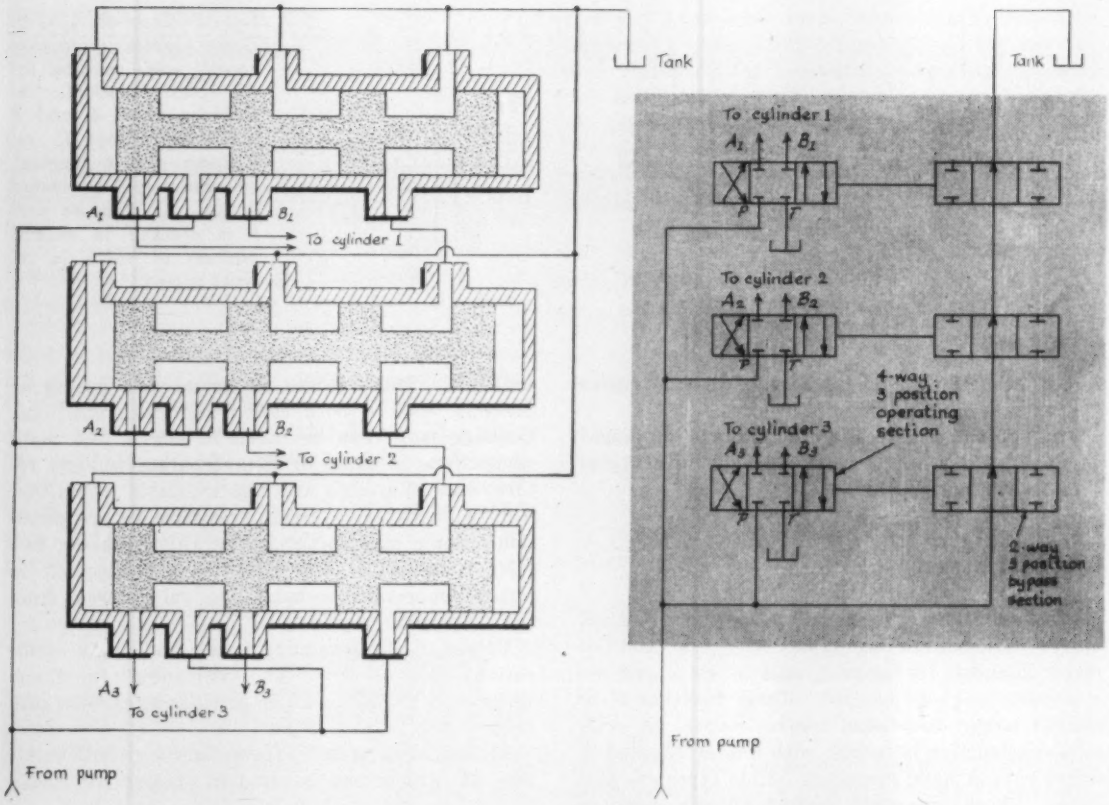


Fig. 33—Circuit for actuating several cylinders in multifunction machine. Right hand section of each directional valve is a two-way, three position valve that bypasses oil to tank in neutral position. Movement of any valve slide away from neutral blocks bypass path and actuates associated cylinder according to direction in which slide is moved. Valves of this type are available in "stacking" form, *Fig.* 34.

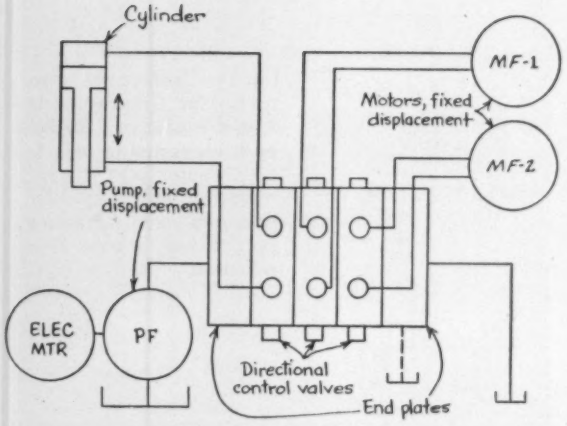


Fig. 34—Directional control valves of *Fig.* 33 may be "stacked" in required quantities. Addition of end plates completes assembly so that only actuator, pressure, and tank lines need be connected.

the main operating cylinder during a rapid approach motion of the cylinder produced by gravity or by smaller approach cylinders.

Deceleration valves are available, usually for cam operation. They may be used to slow the speed of a cylinder by gradually reducing oil flow to the cylinder. Valves of this type may include check valves to allow free reverse motion of the cylinder.

Fourth part of this series, to cover servo valves, will appear in the February, 1958 issue.

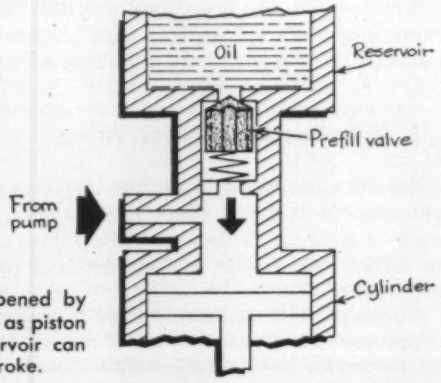
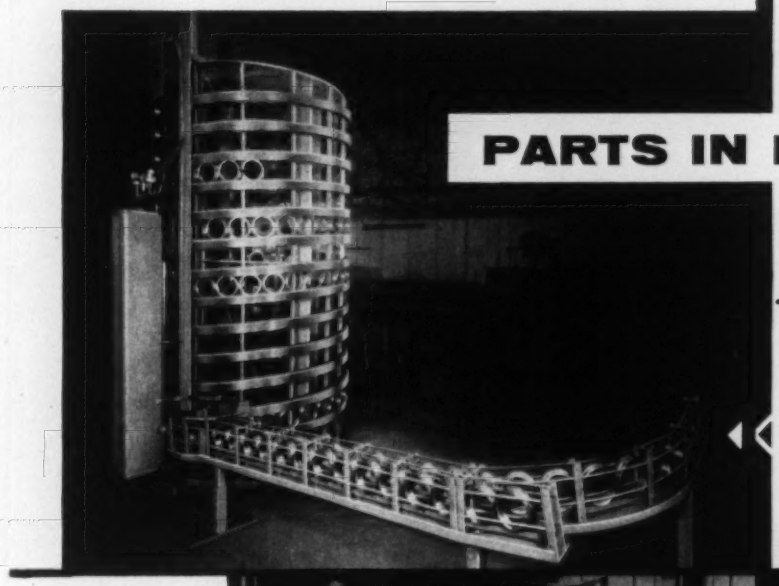


Fig. 35—Prefill valve in this application is opened by partial vacuum developed inside work cylinder as piston descends under gravity force. Oil from reservoir can then fill the cylinder during *rapid approach* stroke.

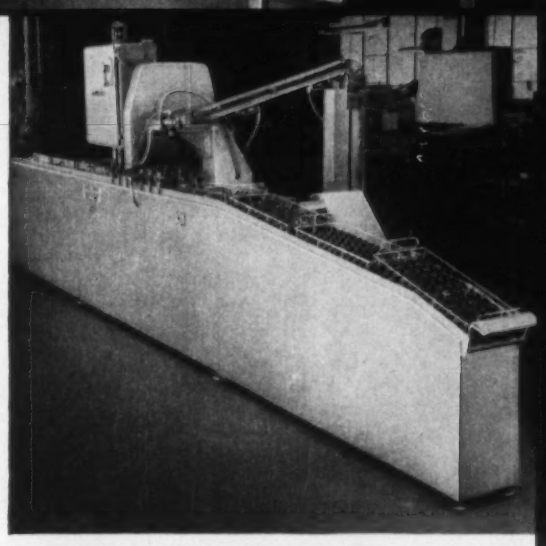
For automating

PARTS IN PROCESS...

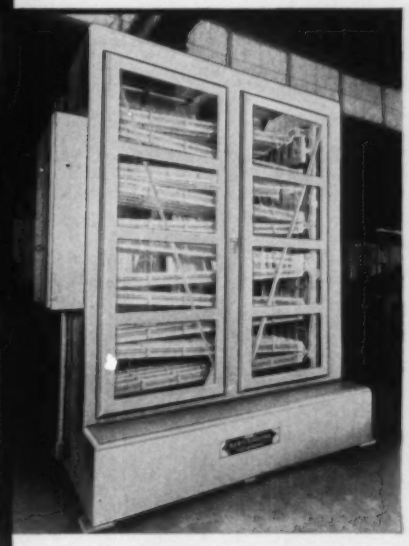
...with { *demand control*
selective feeding
active storage
positive movement



Gear-O-Mation's rotary storage units for parts that can roll. Pneumatically loaded double threads (retaining tracks) store parts for true "as-required dispensing". Custom built for high capacity (Bulletin GO-567).



Gear-O-Mation's high speed equipment for the automatic "basketing" of parts removes a slow-down point of processing. Assembled from standard components, the units are custom-tailored—this one loads center-bored pinions at 3000 per hour (Bulletin No. GO-568).



Gear-O-Mation's process stabilizing unit—a parts bank to insure production continuity. Recently developed for use between operations, the equipment forms an integrated "demand feeding" system. It will check, store and feed from one to more than 5000 cylindrical parts depending on size (Bulletin No. GO-561).

Imaginatively engineered equipment, functionally designed to extend the scope and application of automated production systems, is now in manufacture at Gear-O-Mation. Not just work-handling or transfer units, but packaged units that offer positive control at any point installed. Gear-O-Mation also manufactures part washers, size classifiers, machine loaders and unloaders, elevators, and other equipment—for semi- or full automatism in large or small plants. Write us for details.

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DIVISION OF MICHIGAN TOOL COMPANY
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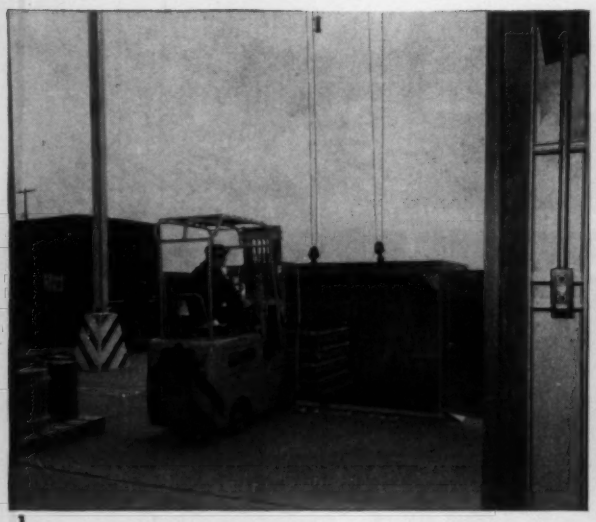

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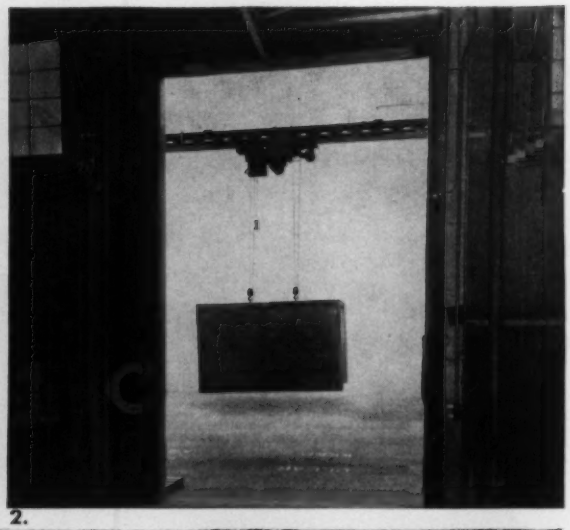
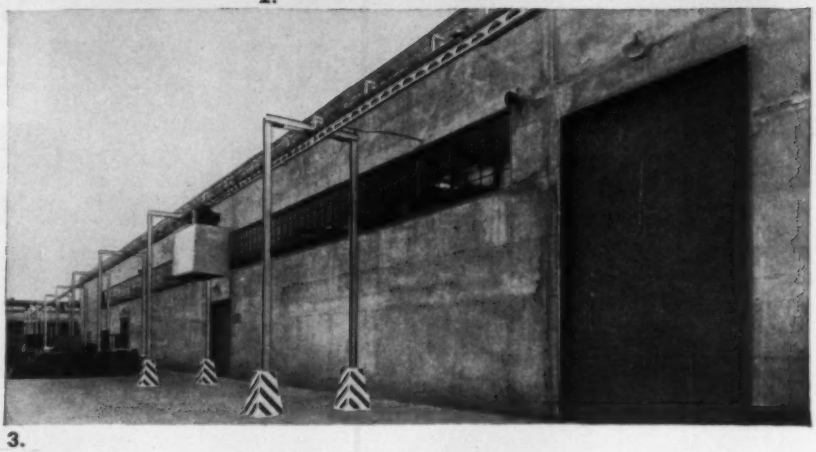


2.

1. Loading carrier van with power truck.
2. Up she goes. Depressing wall button sends carrier on its way.
3. En route to another building.



3.

Robot Carrier Delivers Materials Automatically

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CLEVELAND TRAMRAIL
OVERHEAD MATERIALS HANDLING EQUIPMENT

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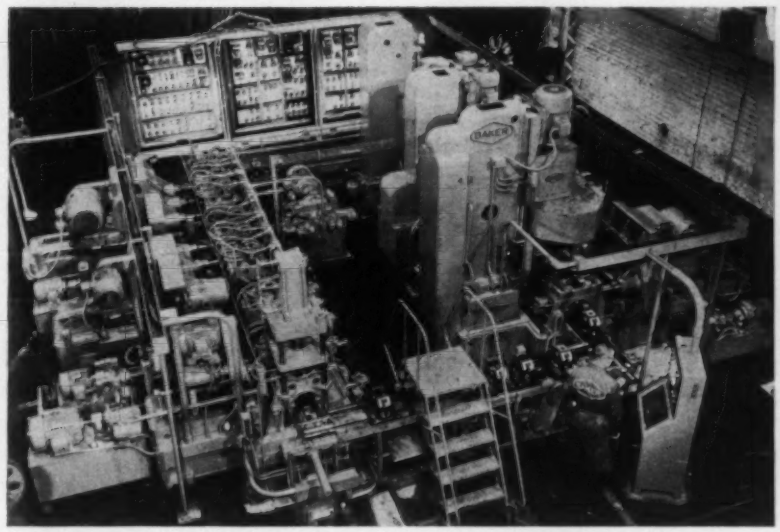
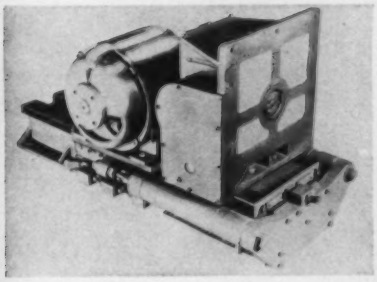
AUTOMATION

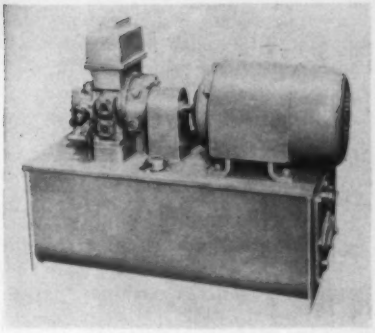
new equipment

Machines and plant equipment for more automatic operations

For detailed information and literature, use card page 17.







Standardized Automatic Components

PRODUCTION MACHINES of "building-block" construction are becoming increasingly popular in automatic programs today. "Standardization of as many components as possible will obviously reduce the engineering and manufacturing costs of automation", says Roland Lehr, president of **Baker Bros. Inc.**, Toledo 10, Ohio.

Development of standardized components for fabrication into special-purpose production machines will provide many additional benefits. For example, lead times for filling orders will be shortened. Parts inventories, both at the supplier's factory and in the form of spares at the user's plant, can be reduced. Lower maintenance can be offered the buyer due to the simplification of components that will result from standardization, and because more design effort can be devoted by the same engineering force toward improving the resulting smaller variety of parts. In some cases, availability of standardized, "building-block" type machines may enable manufacturers who otherwise could not afford to participate, to share in the benefits of automation.

Two questions were asked in reviewing the designs of previous Baker machines. "What components of these machines could have been standardized," and "How many sizes and types of standard components would have been necessary?" The answers to these questions resulted in a line of standard components for hydraulic slides, drive boxes, and power sources for hydraulic feed. These components are being incorporated in single units and many of the more complex transfer machines. Accessories such as heads and tooling can be added for special jobs. The complete standard unit can be automatic down to loading and unloading devices and conveyors.

Model 1215 (top illustration) has twin-pull hydraulic feed cylinders, saddle, ways, limit switches, and switch cams. The slide can be mounted in any plane. The slide with a 15 hp drive box (middle illustration) is a standard model. The hydraulic feed unit (bottom illustration) for the slide and drive box is one of two standard power sources available. Future plans for Baker Bros. include standardization of bases, spreaders, frames, heads, etc.

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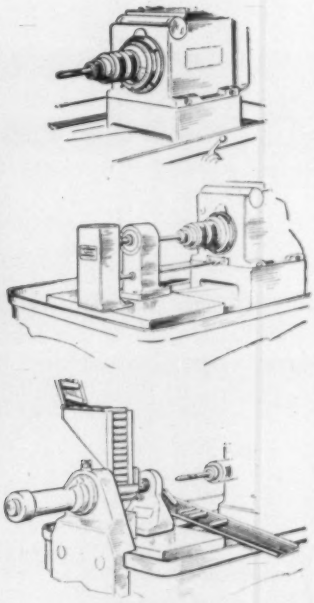

Basic Semiautomatic Unit

Item 402

Semiautomatic honing machine designed for versatility and economy to fill the gap between the large mass producer and the small shop. Model 150 is built as a horizontal type machine with a stationary bridge to accommodate work fixtures and optional equipment, allow for additional automatic work handling devices, and simplify changeovers from one job setup to another.

Basic unit consists of automatic stroking and control, hydraulic tool expansion and collapse, adjustable head for manual tool feed expansion and stone wear compensation, spindle, variable speed drive for spindle rotation, work table support, and electrical equipment. Machine has a 12-inch stroke, and 1½-inch work diameter capacity. The spindle is mounted on a reciprocating carriage, hydraulically actuated. Machine base is cast in one piece.

Designed on the "building-block" plan, the unit can be partially or fully automated by the addition of standard package units. The feed unit (top illustration) includes an automatic stone wear indicator and compensator. The sizing unit (middle illustration) can be either gage plug or gage ring type. The addition of automatic work handling devices (bottom illustration) brings the unit to fully automatic operation. **Micromatic Hone Corp.**, 8100 Schoolcraft, Detroit, Mich.

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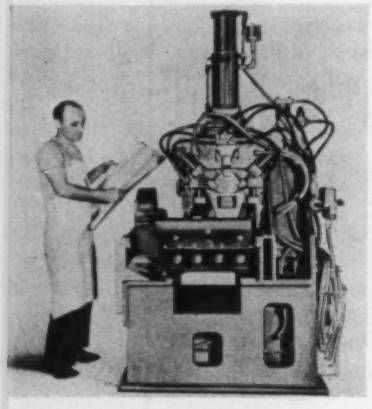

Automatic Marking Unit

Item 403

Machine marks consecutive serial numbers on engine cylinder blocks. This number identifies each block with its corresponding bore size so subsequent operations and assembly can be successfully coordinated. In the application shown, the machine can consecutively and automatically mark from one to four-digit numbers 5/16-inch in size to a depth of 1/64-inch at a production rate of 968 parts per hour. Marking capacity of the machines for other applications can range from one to ten-digit numbers.

Marking head units are powered by air cylinders. Downward movement is controlled by a toggle arrangement. As marking head advances towards the part within a fraction of an inch of the marking surface, air is supplied to cylinders that provide an oscillating or rocking motion to the marking head. The motion continues as the head advances into the material. This oscillating principle can enable thin wall sections to be marked without cracking, and increase longevity of the marking die and all machine components. **New Method Steel Stamps Inc.**, 149 Jos. Campau St., Detroit 7, Mich.

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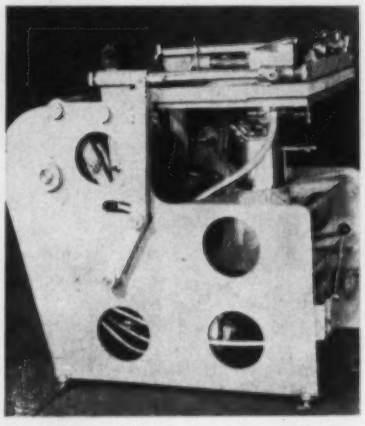

Circuit Printer

Item 404

Designed for silk screen printing of etched circuit blanks, unit is also suitable for printing decals and instrument panels. Ink flow is controlled by fountain settings and squeegee pressure controls, allowing high speed and reducing waste and clean-up. Register is achieved by micrometer dials graduated in one-thousandths of an inch. Production rate is up to 1000 impressions per hour. Standard equipment includes clutch operation, enclosed Masterscreen ink fountain, machined aluminum vacuum platen, throw-off, screen frames, and production center. **Masterscreen Printing Equipment Corp.**, P. O. Box 707, Stockton, Calif.

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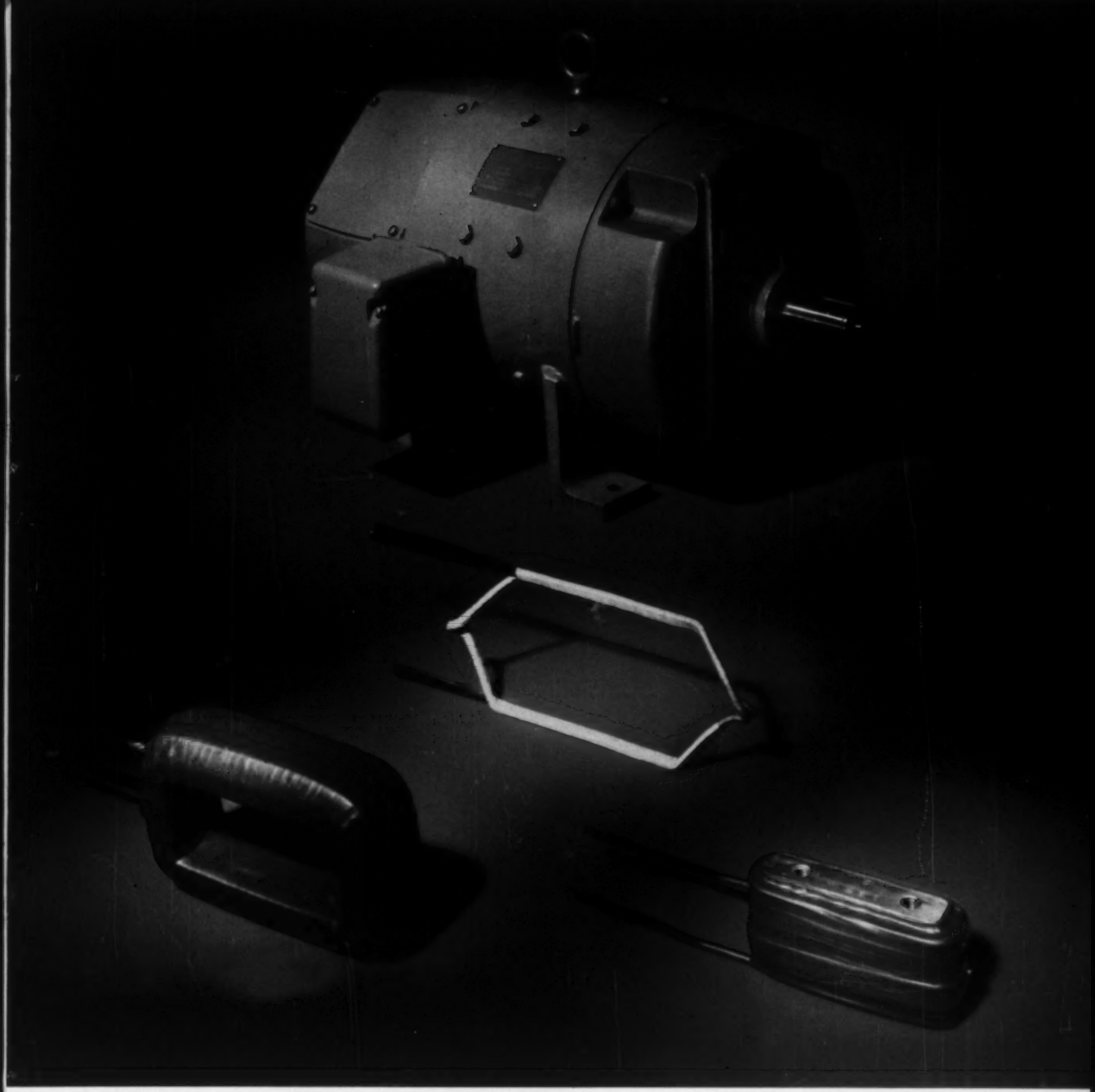

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KINAMATIC* *. . . a new standard in industrial direct-current motors* . . . designed to give extra dependability to automated production systems.

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Greater Versatility . . . a 15% service factor now available in the standard, dripproof d-c Kinamatic motor means user can: 1) obtain 15% more than rated power for normal life of motor; 2) obtain 100% longer motor life at rated power; or, 3) obtain greater versatility on speed and horsepower duty cycles.

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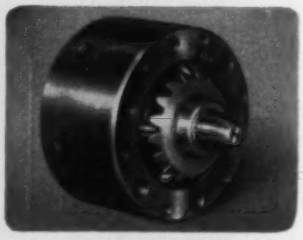

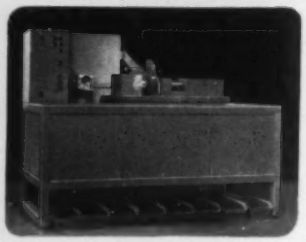

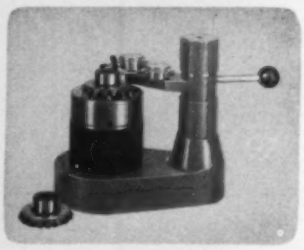

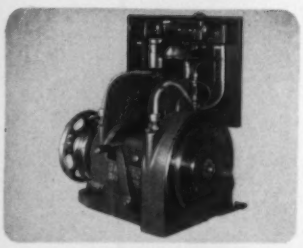

For more than half a century, people with ideas or troubles have found that Garrison usually offers them a prompt solution at a price they can afford.

Our development of automated gear chucks several years ago is typical. A machine tool builder's engineer visited our plant and outlined the requirements for output and accuracy. A few days later we submitted our final layout of a package unit which met all requirements and has since proved itself by production records covering millions of finished parts in many plants.

Another firm explained that their best opportunity for cost reduction lay in assembly rather than production. Could we produce one machine that would rapidly inspect and sort various types of parts into eight categories—and deliver it in time to meet their schedules? Within ten days we started fabrication of the machine.

A leading automobile manufacturer needed a rugged inspection fixture for shop use to check gears at various stages in production in order to eliminate rejects promptly and signal the need for a correction in machine settings. They suggested that we use our production chucks as the basis for their inspection fixture. This use of our production chucks as gages in quality control programs is, obviously, a compliment to the workmanship and standards which are routine in our plant.

When a special machine required dimensional stability and tapered plain bearings to achieve accuracy and finish beyond anything available, we developed THERMAL CONTROL. It is available to any individual or firm on a very liberal license plan.

A manufacturer of fuel injection units encountered difficulties inspecting parts which had to be held to tolerances of a few millionths—and the problem became more difficult (quite naturally) when the operation was transferred to an air-conditioned gage laboratory. We quickly ended the difficulty by supplying a THERMO-LAB which is a necessity for laboratory precision operations of manufacture, inspection and assembly.

If you have a problem or an idea—and you want results at a price you can afford—contact us.

GARRISON MACHINE WORKS, INC., DAYTON 4, OHIO

Established 1904

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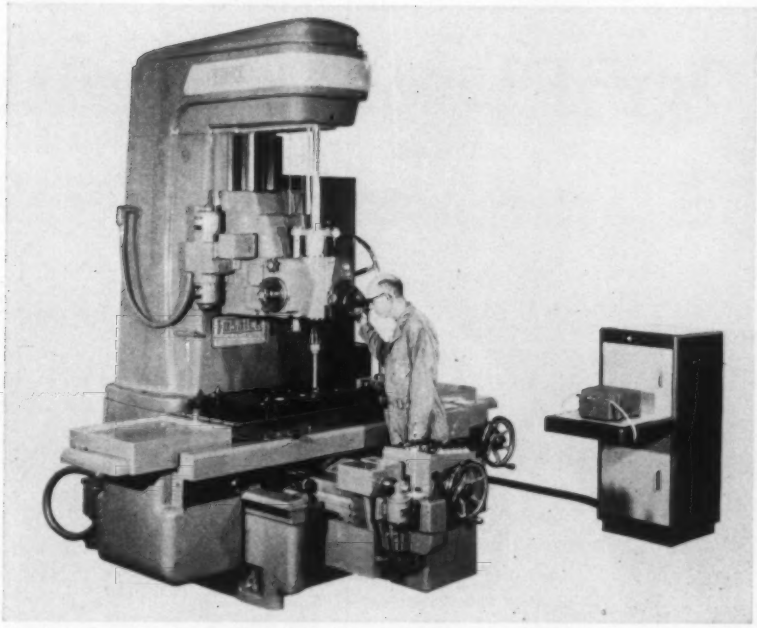

Tape Controlled Jig Borer

Item 405

Suitable for small and medium production runs, Model 54P provides close tolerances without special jigs and fixtures. In operation, the operator loads the part to be machined on the jig borer table, presses a button which positions the table to ±0.0001-inch and sets the spindle speed and feed according to values punched in the tape. Dimensions from part prints are punched directly into the tape eliminating the need for coding.

Tape can be stored away so production runs of the same part can be repeated. The measuring system used allows the table to be positioned automatically to limits of ±0.0001-in. The gages are selected by motor-driven drum dials and positioned end to end to provide the required measurements. Movement of the table stacks the gages and moves them to operate a switching mechanism. At the point of final position, the table movement is stopped, the traverse screw is relieved by reversing it slightly and the table is clamped. The borer provides 16 speeds from 30 to 1800 rpm controlled by electromagnetic clutches. Eight feed rates from 0.0005 to 0.010 ipm can be selected. **Fosdick Machine Tool Co.,** Cincinnati 23, Ohio.

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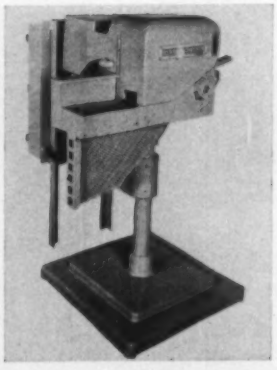

Gear Classifier

Item 406

Machine sorts gears into size ranges for assembly operations. It is adapted to the production of gears such as those used in planetary and related types of gear sets where equalized backlash and loading conditions are desired in finished assemblies. Accuracy of size measurement is achieved by utilizing a double-pivoted mounting for the upper non-rotating master gear, and synchronized engagement of the same tooth of the motor-driven lower master gear with each gear to be measured.

Pinions are fed into the classifier from the production line. The size measurement is made by passing each pinion between a pair of master gears. Center distance movement of the upper master gear as each pinion passes through is measured by the sensing unit of a linear variable differential transformer type. Electronic controls amplify the signal from the transformer and cause solenoids to open a door in the exit chute of the classifier which corresponds to a particular size reading. The pinions are automatically measured, classified, and directed into proper size chutes for the assembly operation. **National Broach & Machine Co.,** 5600 St. Jean Ave., Detroit 13, Mich.

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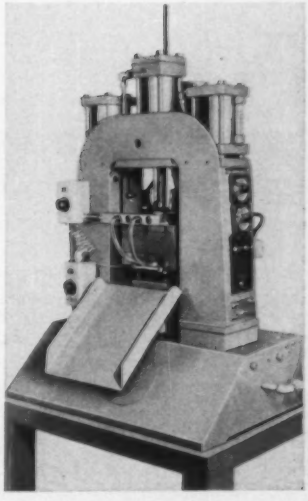
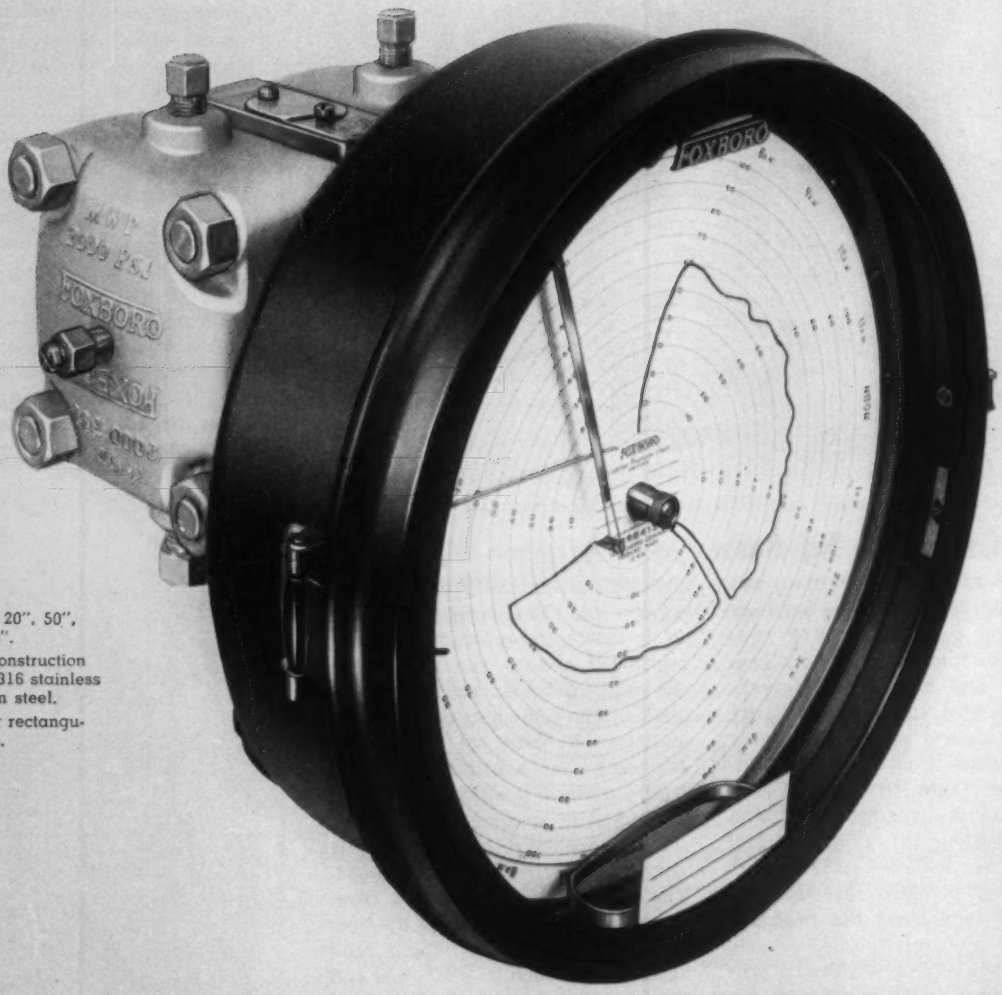


Molding Press

Item 407

Suitable for short production runs, Model A10 uses an air-hydraulic principle. The molder uses his present air supply as a source of power, with a normal working air pressure of 80 to 100 psi. With 80 psi working directly on oil, the ram moves into position on low pressure and the booster steps up the pressure to 20,000-lb ram force at any desired location within the 6-inch stroke of the ram. A safety valve prevents overstressing the

NOW... a "Dry" Flow Meter with...

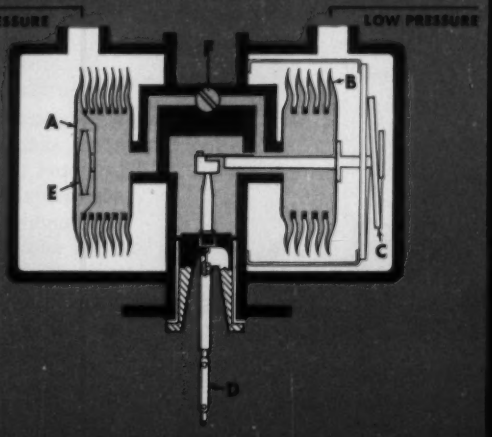


- Ranges: 20", 50", 100", 200".
- Forged construction in Type 316 stainless or carbon steel.
- Round or rectangular cases.

...the new Foxboro Type 37 Diaphragm Meter

How It Works

In schematic drawing at right, areas shown in color represent a stable, non-freezing liquid. Any pressure increase in the high pressure chamber compresses Diaphragm Unit A, displacing its liquid and expanding Diaphragm Unit B until force of Range Spring C equals the difference between the forces on Diaphragm Units A and B. Linear motion of Diaphragm Unit B moves inner end of Drive Bar D — outer end moves correspondingly through the bellows-sealed flexure bar, driving pen arm. Built-in Temperature Compensator (E) proportionately adjusts diaphragm capacity as ambient temperature variations affect volume of filling fluid. External damping adjustment is shown at F.



•complete overrange protection!

•sustained high accuracy!

Now you can have mercuryless flow measurement for a wide range of differential pressures — at static pressures up to 2000 psi — with greater safety and dependability than ever before! The new Foxboro Type 37 Diaphragm Meter not only combines unmatched ruggedness and precision in a dry meter — it's by far the easiest to adjust and maintain. And it does away with zero drift problems, once and for all! Expansible, Type 316 S.S. diaphragm elements respond to changes in pressure with unmatched sensitivity, yet are completely immune to overrange up to full static pressure! A unique packless drive bar precisely transmits linear motion to the pen arm. Range-changing is easy, due to new twin-spiral spring design. Wide range damping is externally adjustable under pressure. And the Type 37 is self-compensating for temperature changes in all differential ranges. Get full details on this high utility, completely dependable dry flow meter. Arrange for a demonstration with your nearby Foxboro Field Engineer, or write The Foxboro Company, 1212 Norfolk St., Foxboro, Mass., U.S.A.

FOXBORO

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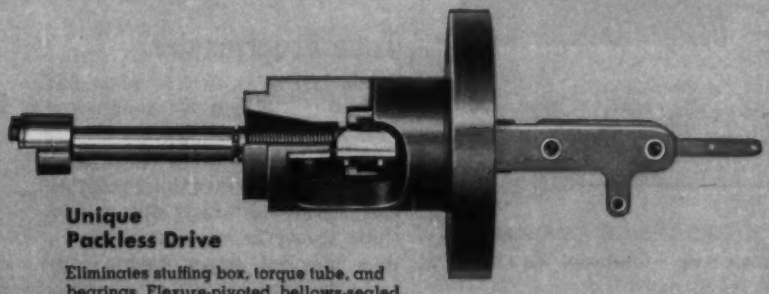
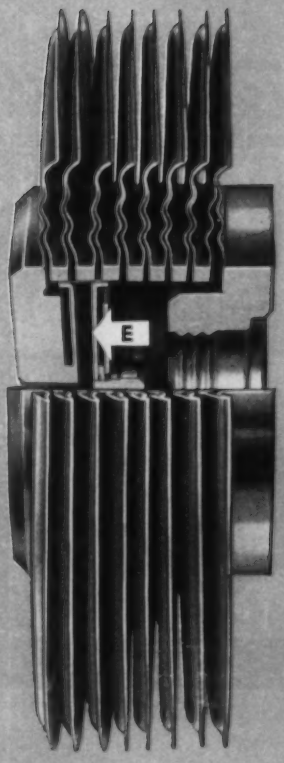
FIRST IN FLOW METERING



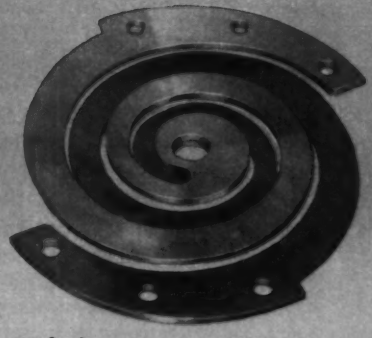
Unique Packless Drive

Eliminates stuffing box, torque tube, and bearings. Flexure-pivoted, bellows-sealed drive bar transmits diaphragm's linear motion to the pen arm with unequalled sensitivity *and undiminished power*. Seal for flexure pivot is a tough, flexible bellows.



Exclusive Diaphragm Elements

Type 316 S.S. diaphragm units in both high and low pressure chambers provide greatest linearity and freedom from hysteresis; nesting design and integral spacer rings provide safe, positive, overrange protection. Temperature compensation (E) is built into diaphragm assembly . . . *never* requires change or adjustment.



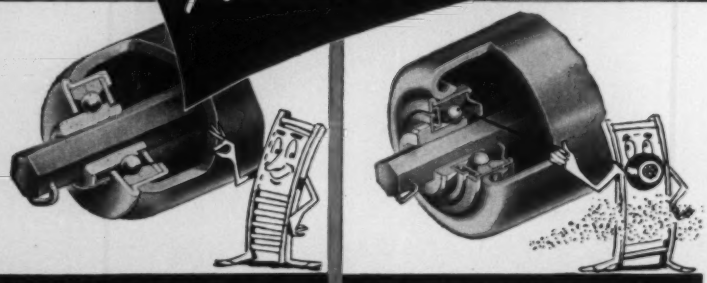
Exclusive Range Springs

Heavy gauge Ni-Span C alloy, twin-spiral springs provide high sensitivity with lasting accuracy. Readily accessible . . . range changes are easily made, in minutes!

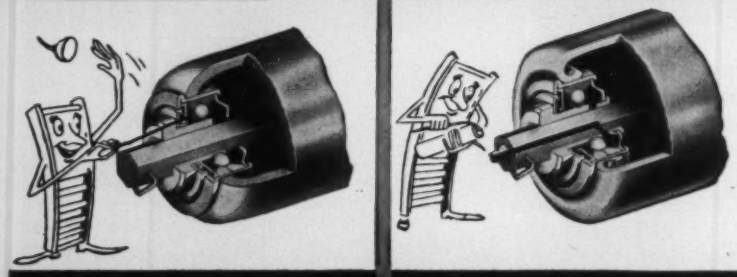
Circle 675 on Page 17

Better Built

BUSCHMAN ROLLER CONVEYORS Feature:



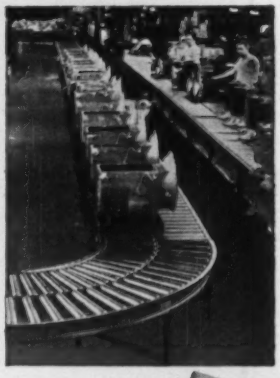
Plain Ball Non-Lubricated Bearings | Dustproof Labyrinth-Sealed Bearings



Grease-Packed-For-Life Bearings | or Pressure Lubricated Bearings

TO MEET YOUR REQUIREMENTS

In roller conveyors, it's the bearing that counts! And BUSCHMAN conveyors use only performance-proven bearings... engineered for long life and trouble-free operation in every type of service. No matter what normal operating conditions may be, BUSCHMAN has a conveyor pre-engineered to meet your needs.



Conveyors are available with various types of rollers and frames, in different sizes and spacings, and in any width from 6 inches on up. BUSCHMAN can supply 45° and 90° curved sections, switches, spurs, work stations and other components to provide a complete, efficient materials handling system.

For Complete Details, Write For 16-page Catalog No. 60 Today.

PRODUCE MORE ... FOR LESS on Buschman Conveyors

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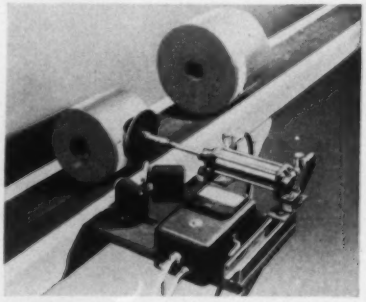
mold frame, which is capable of handling a 5 x 6 inch chase plate. Replacement of the core and cavity is made by removing four screws that hold the members to the chase plates and inserting new ones. The electrical system is mounted on one panel board, and all parts on the machine are accessible for fast servicing. **Automatic Molding Machine Co.**, 3201 Exposition Place, Los Angeles 18, Calif.

Circle 407 on Page 17



Roll Transfers

Item 408

Unit operates with light source, photoelectric cell, and air cylinder. Photoelectric cell detects various colored labels and actuates the air cylinder push-off device. Various labels can be detected and pushed off the troughing belt conveyor. When a package or roll is to continue through, the package is turned so that the label does not pass the light beam. **Sage Equipment Co. Inc.**, 30 Essex St., Buffalo, N. Y.

Circle 408 on Page 17

Tape Programmer

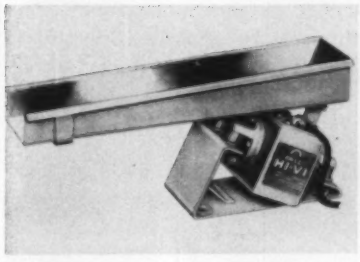
Item 409

Unit is suitable for sales analysis, labor distribution, accounts payable, expense distribution, back order control, inventory control, and integrated order billing. Machine converts calculator results into punched paper tape, ready to be fed into processing machines

with tape-reading mechanisms. A program board which automatically punches constant data such as code numbers into the tape, speeds the operation. The tape is fed into a tape-to-card converter for automatic re-use on data processing equipment, or into a teletype for automatic wire transmission to other offices.

Through the program board, the unit enters constant data into the tape and when the operator presses the read-out key, information is automatically read-out into the tape in proper sequence. Up to 102 program steps can be used for each read-out sequence. The calculator can be used independently of the tape-punching unit and can be disconnected for portable use. **Comptometer Corp.**, 1735 N. Paulina St., Chicago 22, Ill.

Circle 409 on Page 17



Vibratory Feeders

Item 410

Units in new line provide accurate, controlled feeding of bulk materials from ounces to tons per hour. All types of materials; dry, hot, abrasive, or lumpy can be conveyed, spread, agitated, blended, cooled, dried, or mixed. Drive element in the feeder is completely enclosed, providing protection against damage or contamination by moisture, chemicals or foreign materials.

Model HI-VI has rectangular shaped trays which produce uniform feed and smooth spread or flow. The compact base gives flexibility in side-by-side, back-to-back, or tandem installations. Feeder can be fastened to a component, without the base. It operates at 3600 cpm directly off an ac line. **Eriez Manufacturing Co.**, Erie 6, Pa.

Circle 410 on Page 17

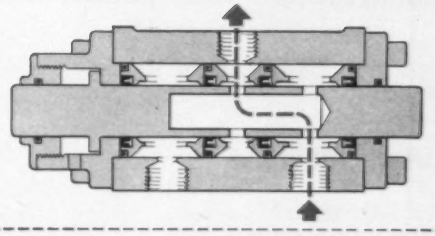
WHO says all control valves are pretty much alike?

This exclusive patented*

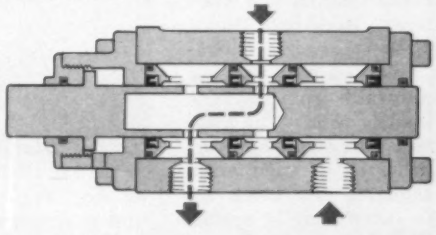
Quick-As-Wink®

construction

Plunger Right. Air flows through the inlet—and the hollow, polished stainless steel plunger—and out to the air operated device.



Plunger Left. Inlet air is blocked off. Air from the air operated device is exhausted through the hollow plunger, and out the exhaust connection.



assures users unparalleled efficiency, economy, dependability and satisfaction

Quick-As-Wink Control Valves are in a class by themselves! Our exclusive patented* valve chamber construction, that accurately positions the "O" rings and the "U" packers without mechanical pressure, meets the most exacting service requirements. No direct flow across the packings, greatly prolonging their life. No lapped joints. No metal to metal seating. Hundreds of different types and actions. Sizes from ¼" to 4". Get full details.

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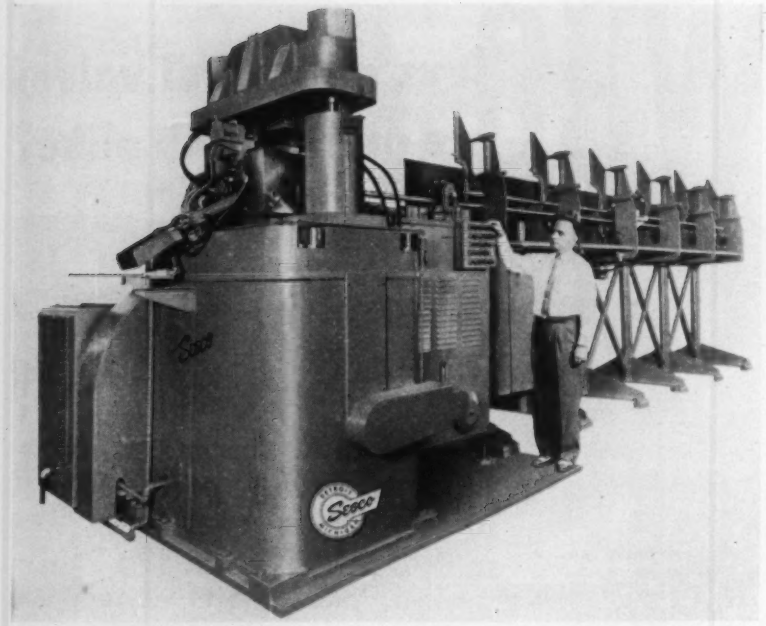
Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves

Mfd. by **C. B. HUNT & SON, INC.,** **2075 East Pershing St., Salem, Ohio**

Engineering and Sales Representatives in the Principal Cities

Circle 677 on Page 17



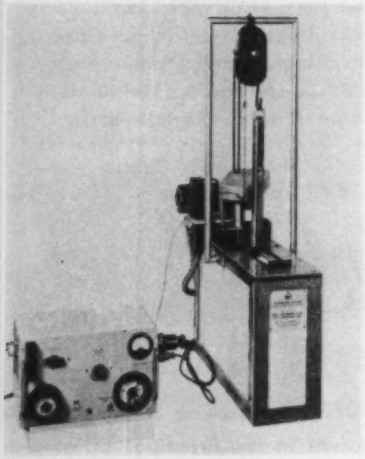
Bar Cutoff Machine

Item 411

Machine receives and processes bars of random lengths and various diameters. Bars are loaded on the bar storage rack. Operator pushes a button and one bar is fed automatically from the rack to the bar loading rolls. The loading rolls then carry the bar forward to the bar cutoff gage, automatically engaging the stock retainer. The cutoff unit is cycled, cutting the bar lead and disposing of the scrap.

When the trail end of the bar passes a predetermined point, a signal is sent to the bar storage rack, causing it to feed another bar to the loading rolls. The new bar progresses to the cutoff gage and the cycle is automatically repeated. Bar leads and trailing ends are treated as scrap and separated from the good parts. Bar is fed to the cutoff unit by the feed unit; gripper jaws extend forward to permit feeding close to the cutoff die. The crank operated cutoff unit is clutched and braked by air. A hydraulic tank unit in the base of the feed unit houses the motor, pump and valves. **Sesco Inc.**, 8881 Central Ave., Detroit 4, Mich.

Circle 411 on Page 17



Printed Circuit Solderer

Item 412

Unit lifts the molten solder up to the printed circuit instead of lowering the circuit panels down to the molten solder. The solder is raised up to the circuit panels by an impeller pump, which forces the metal upwards through an elongated nozzle so that it forms a stationary wave. The panel is passed through the crest of the wave of molten solder, which solders the joints between the component leads and the copper conductors on the underside of the panel.

Unit consists of a dipping bath that holds approximately 500 lbs of metal. Fresh solder is fed to the bath by feeder ingots; as the solder is consumed the ingot is gradually lowered into the bath. The unit is electrically heated. Solder temperature is thermostatically controlled. Device automatically provides angled entry and exit by the shape of the solder wave, and with the washing action of the moving solder, prevents trapping of flux or air and assures sound joints.

The panels automatically move along a straight path, preventing hesitation or break in the production flow. The panel passes through a wave of constantly flowing solder and provides rapid heat transfer from solder to panel. Surplus solder drains back into the bath so that it does not form "icicles" or bridges between adjacent conduits. Height of the wave level is regulated by adjusting the speed of the metal pump which forces the molten solder through the nozzle. **Electrovert Inc.**, 489 Fifth Ave., New York 17, N. Y.

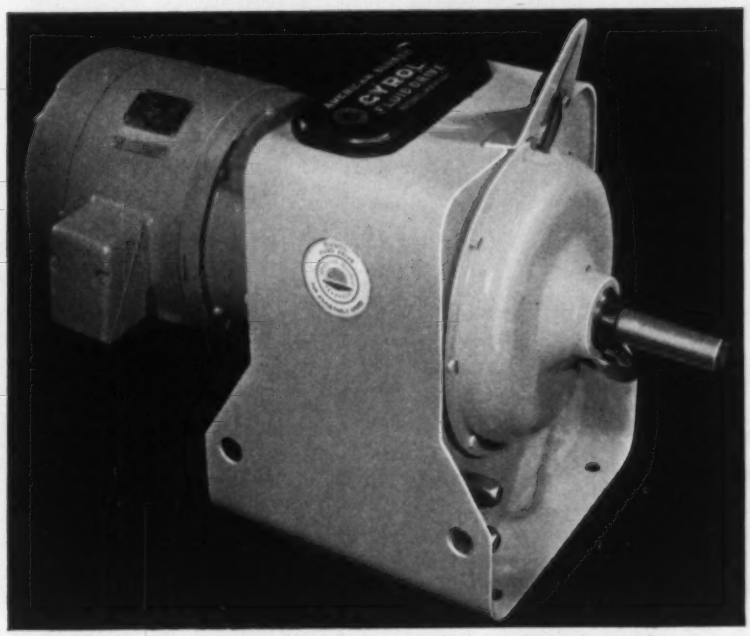
Circle 412 on Page 17

Precision Welder

Item 413

Automatic machine for welding titanium. A gas-tight seal plate is provided under the round, 8-slot precision machined table. Plate allows the user to place a plastic gas-tight dome over the table and workpiece to weld in gaseous atmosphere. Preset on an electrical panel, the controlled rotation includes variable speed and fast positioning, powered tilting and powered elevating. Table tilt gearmo-

Why you should include Gýrol® Fluid Drives in your plans for automation



Compact, flange-mounted Type VS, Class 2 Gýrol Fluid Drive — 1 to 25 hp.

For one thing, Gýrol Fluid Drives provide adjustable, *stepless* speed control of driven machinery, using *standard*, constant-speed motors — without complicated electric circuits or starting devices.

Adaptable to remote, manual, or automatic speed control, Gýrol Fluid Drives are compact, self-contained units — requiring only the conventional flexible-coupling connections to the motor and load. They provide complete shock absorption, are easy to install in a variety of arrangements of driving to driven machinery. Why not call our nearest branch for full details today?

Typical Applications

PUMPS, AGITATORS, MIXERS

CONVEYORS, CABLE & ROPE MACHINERY

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CENTRIFUGAL COMPRESSORS

PAPER AND PRINTING MACHINERY

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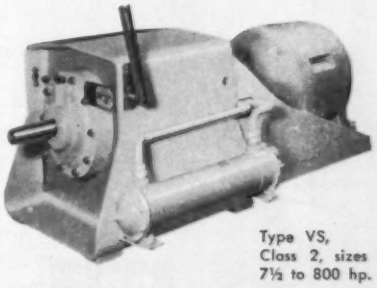
Complete range of sizes — 1 hp to 12,000 hp

The Gýrol Fluid Drive line includes a complete range of sizes, from 1 to 12,000 hp. All save power through lower horsepower requirements. A minimum number of wear points cuts maintenance. And, because Gýrol Fluid Drives bring about reduced speeds and pressures, driven equipment lasts longer.



Type VS, Class 2, sizes 7½ to 800 hp.

American Blower products serve industry

- Air Conditioning, Heating, Ventilating Equipment
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- Gýrol Fluid Drives
- Dust Collectors
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American Blower Division of American-Standard, Detroit 32, Michigan
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AMERICAN BLOWER

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QUALITY PROTECTS YOUR INVESTMENT... AMERICAN-Standard QUALITY IS AVAILABLE AT NO EXTRA COST

Circle 678 on Page 17

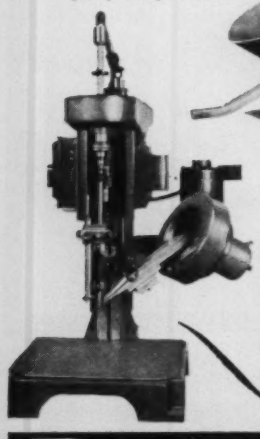
Industrial GIANT or One-Man Shop

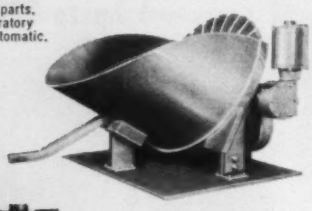
DPS *Engineers*

CAN SOLVE YOUR ASSEMBLY PROBLEM!

BOWL FEEDER
for light, fragile parts. Operates on vibratory principle. Fully automatic.

● **For assembling operations large or small, intricate or simple, we are prepared to take care of your requirements. If you have a feeding or assembling problem, though seemingly difficult, don't hesitate. Write today, send sample assembly, give details.**





BARREL FEEDER
with stationary ring cover for heavy-duty production.

DPS
All-Purpose
SELECTIVE PARTS FEEDERS

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5 MACHINES
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BARREL FEEDER
conventional, motorized type, for parts requiring critical selection.

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tor and elevation gearmotor have magnetic braking and adjustable precision limit switches. Rotation motor and transmission are equipped with a clutch-brake. Positioner table has roller backups. All shafts are free running on antifriction bearings. Electrical panel and pushbutton station are dust-tight, oil-tight, and relays are provided for additional hook-ups. Controls are on 110v control circuit. **Aronson Machine Co.**, Arcade, N. Y.

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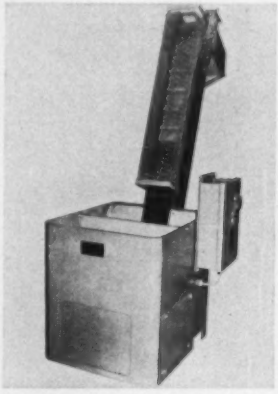


Elevating Bulk Loader

Item 414

Cycled for automatic loading of a vibratory feeder, Model 2400 is self-contained, and is powered by a ½-hp motor and variable speed drive with electrical controls. Parts are picked up from the hopper by metal cleats on the moving conveyor and elevated to the vibratory feeder. Loader can be modified to feed rolling or sliding parts in a wide range of sizes. Capacity of the hopper is 4 cu ft which provides large storage space to suit production variations. **Feedall Inc.**, 38399 Pelton Rd., Willoughby, Ohio

Circle 414 on Page 17

Automatic Printer

Item 415

Automatic card-to-card printer reproduces microfilm mounted in aperture cards. Machine can duplicate microfilm negatives or positives at speeds up to 2000 cards an hour. Units can be geared to handle punched cards. Film for the duplicates can be of the am-

THIS AIR CYLINDER ACTS 78 MILLISECONDS FASTER

Take a 2½" bore conventional air cylinder, connect it to a remote valve with 6 feet of ⅜" diameter hose. *123 milliseconds* after the valve is operated, the air cylinder's piston begins to move.

Now take a Bellows Air Motor (the air cylinder with the *built-in* valve) of the same bore. The response time for the Bellows Air Motor is 45 *milliseconds* . . . only 27% of the time required by the remote-controlled air cylinder.

Multiply that time-saving over an eight-hour shift . . . using, say, a six-parts-per-minute operation . . . and you receive 44 more parts each shift from your machine when you use a Bellows Air Motor with the built-in valve.

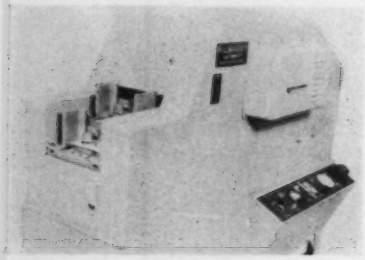
"Forty-four more parts each shift?" Not many, perhaps. But the multipliers . . . number of machines, number of shifts, length of production run, any one or all of them . . . can send the "44" up into respectability very quickly. In fact, it can mean 33,000 more parts per year from a single machine.

Quick response is only one of many advantages integral valving offers the user of air cylinders. Positive speed control; uniform power thrust; less air consumption; no cumbersome piping . . . all of these make an impressive total of cost saving advantages.

GET THE FULL STORY — Write for Bulletin BM-25. Twenty pages of helpful data every production man can use in his battle for lower costs. Address Dept. AU-1257, The Bellows Co., Akron 9, Ohio. In Canada: Bellows Pneumatic Devices of Canada, Ltd., Toronto, Ontario.

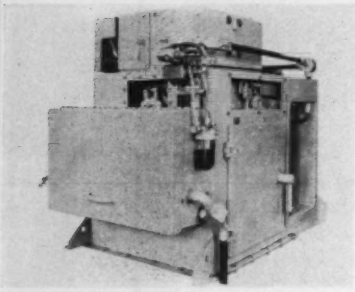
924B

The Bellows Co.
AKRON 9, OHIO



monia fume processing or controlled heat processing types. Standard machine is rated for 115v, 30 amp, 60 cycle ac. An 800 w short-arc mercury vapor lamp is used as the light source for copying the image from original to duplicate film card. **Filmsort Div., Dexter Folder Co.,** Pearl River, N. Y.

Circle 415 on Page 17



Bulk Weighing Scale

Item 416

Instrument gives precise weight of products such as Fuller's earth, flour, aluminum sulphite, bauxite, starch, clay, fluorspar, and a variety of resins and plastics. A flush-proof air-powered hopper door seals and locks under pressure. The positive seal is provided by a special rubber ring on the hopper door which fits into a rubber bed on the hopper itself. The rubber is vulcanized directly on the plate and is ground to contour. An air cylinder with a 3-inch bore and a 3-inch stroke powers the door.

Capable of weighing up to 200 lb per draft, Model E-50 operates on a free weigh-beam principle with sealed test weights in the weight box balanced against an equal mass of material in the hopper. Normal speed range is up to ten weighings a minute. Features of the scale include a locking gear that prevents entry of unweighed material through inlet gate when hopper door is open, and a six-figure counter for tabulating scale discharges. **Richardson Scale Co.,** Van Houten Ave., Clifton, N. J.

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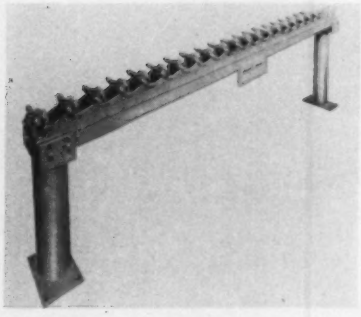

Storage Track

Item 417

Device moves parts by gravity. It has a small capacity float which can be used for any part that can roll. Track prevents collision by letting the weight of the first part depress the downstream end of the counterbalanced flipper. This raises the upstream end, stopping the second part. Weight of the second part actuates the second flipper in the same way. The action is repeated at each station as each following part enters the track. When the first part leaves the downstream end, all following parts advance one station. Parts are fully protected against nicks and dents by a soft surface. At no time can two parts touch each other. **Cargill Detroit Corp.,** Birmingham, Mich.

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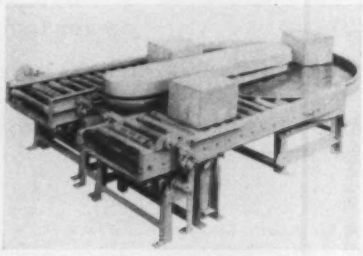

Conveyor Turntable

Item 418

Adaptable for installations in narrow areas or when space is at a premium, conveyor turntable transports cartons, cases, and packages through a 180 degree turn. An endless traveling inner guide belt ensures correct tracking of cartons or cases throughout the turn, and proper discharge onto the receiving conveyor line. A beveled edge on the turntable facilitates transfer from the conveyor line onto the rotating turntable.

Turntable is driven by means of a system of spur gears by a variable speed motor and can be regulated to the speed of the incoming and receiving conveyor lines. Proper tension of the belt is maintained by an automatic take-up. **Alvey-Ferguson Co.,** 1511 Disney St., Cincinnati 9, Ohio.

Circle 418 on Page 17

Gasket Spotting Machine

Item 419

Developed for the automotive industry; device is also applicable wherever gaskets are applied in assembly line operations. Machine spots adhesive on gaskets to hold them in place until an assembly is completed. Used in conjunction with newly developed Armstrong T-922 Hot Melt Adsive, unit contains a tank for heating the adhesive and a thermostatically controlled heating element for keeping the adhesive at the right consistency. A gasket is placed on a bedplate on top of the tank and vertical studs on a hollow frame inside the tank are forced up through holes in the bedplate to bring the adhesive to bear at the desired spots on the gasket. The tank on the machine will hold about six gallons of adhesive, enough for 20,000 to 30,000 gaskets. **Armstrong Cork Co.,** Lancaster, Pa.

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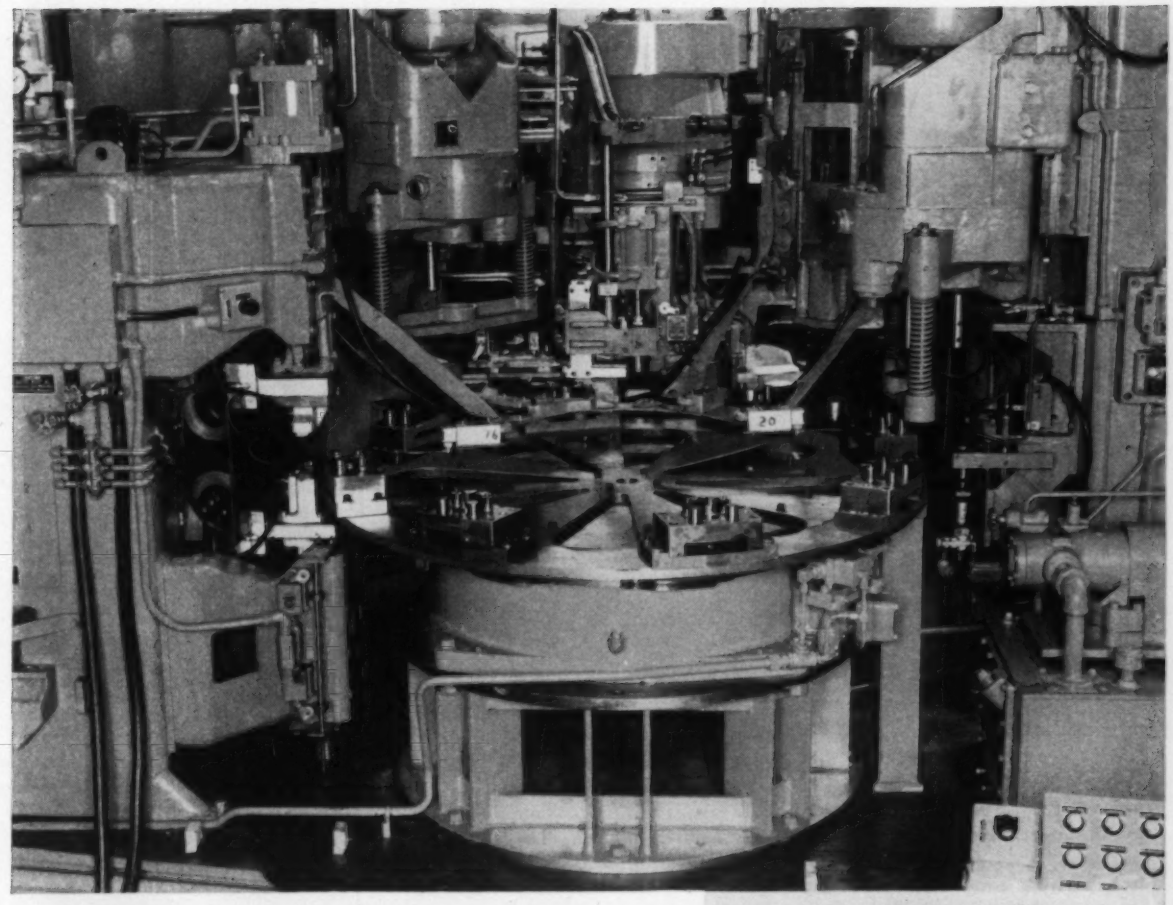
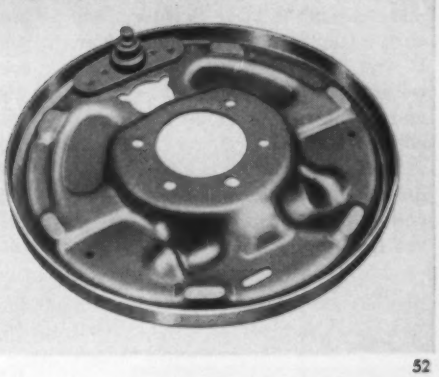


THIS NATIONAL ELECTRIC MULTI-STATION DIAL FEED MACHINE

paid for itself in 9 months!



52

Loading, resistance welding, hydraulic reaming, hopper feeding, pressing, hot upsetting and hollow milling are the seven operations—performed automatically—on automotive brake backing plates by this one National Electric Dial Feed Machine. The installation of this unit, by an automobile manufacturer, not only released eight machines for other production, but saved a corresponding amount of floor space as well.

This is only one example of the money and man-hour savings realized when National Electric Automatic Welding Machines are employed. National Resistance Welders, Gas-shielded Arc Welders and Submerged Arc Welders . . . meet the high-speed assembly-line methods and close tolerances demanded throughout American Industry. A National Electric Welding Machine can be developed to fill requirements of any volume welding job. Write today for information.

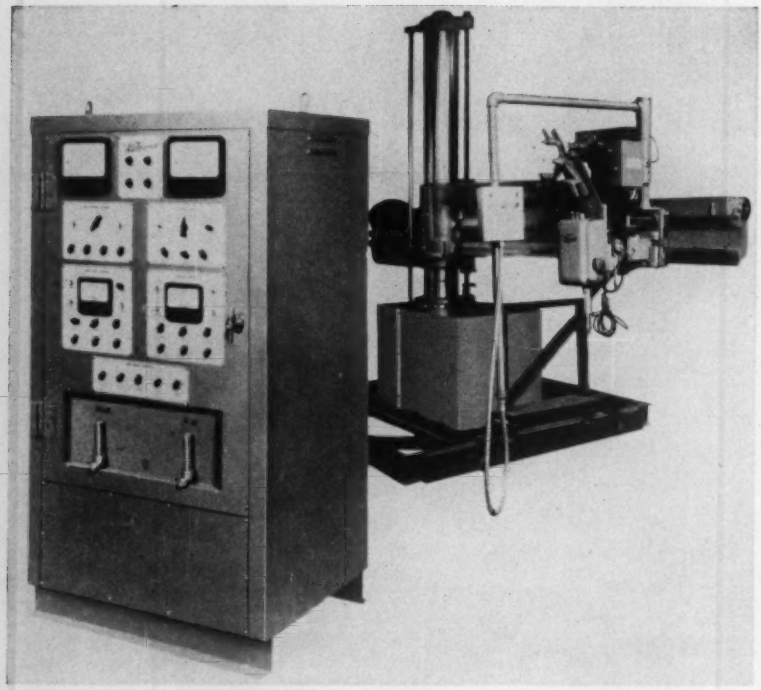
NATIONAL

ELECTRIC WELDING MACHINES CO.

1870 N. TRUMBULL STREET
BAY CITY, MICHIGAN

25 YEARS EXPERIENCE DESIGNING AND BUILDING: SPECIAL & STANDARD • AIR • HYDRAULIC • MOTOR DRIVEN • SPOT • PROJECTION • SEAM • BUTT • FLASH • RESISTANCE WELDERS • PRODUCTION FIXTURES FOR ALL TYPES OF AUTOMATIC ARC WELDING.

Circle 681 on Page 17



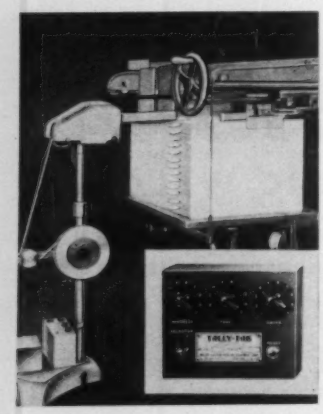
Gas Fusion Arc Welder Control

Item 420

Unit is designed for production welding of hard-to-weld alloys such as titanium and high temperature stainless steels. Control is applicable with an automatic seam and circumferential welder, and with an automatic arc spot welder. It can also be used for manual welding, with regulated current and an automatic slope for crater elimination.

Welder offers flexibility in sequencing, the variable amplitude and time adjusters operating in voltage regulated circuits provide a wide choice of starting, intermediate and finishing settings for the current, for the carriage speed and for the wire speed. The arc power supply, automatic arc length control, wire drive, carriage drive, gas and water controls, and the timer sequence are housed in the console. Control station provides all jogging movements, *weld start, emergency stop,* and manual initiation of current decay on the fusion welding machine. **Weltronic Co.,** 19500 W. Eight Mile Rd., Detroit 19, Mich.

Circle 420 on Page 17



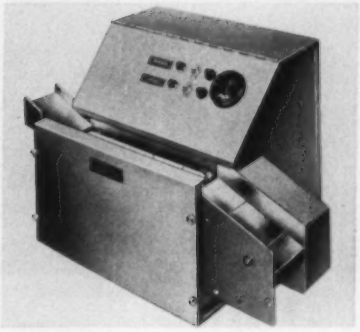
Automatic Counter

Item 421

Device automatically gives positive counting and tabbing for banding strapping, inserting, and boxing. Features of the Tally Tab "1000" counter are instantaneous selection of any count from 1 to 1000; automatic re-cycling when predetermined count is reached; a pilot light indicating that count is being received by the counter; make-up switch allowing operator to subtract any number of sheets or pieces removed from the press or machine for inspection or because they are damaged; protecting cover for inserter head and all moving parts.

The inserter head can be adjusted to any height from 34 to 54 inches and the feed channel can be positioned to reach the smallest sheet at any point on the delivery skid. All units are supplied for 115v or 230v ac, 60c operation. Counter can be actuated from a limit switch, photoswitch, pressure switch or any other type of single pole, single throw device. Read-out counters are available if total count or number of tabs inserted are required. **Miller Lauffer Printing Equipment Corp.,** 280 Lafayette St., New York 12, N. Y.

Circle 421 on Page 17



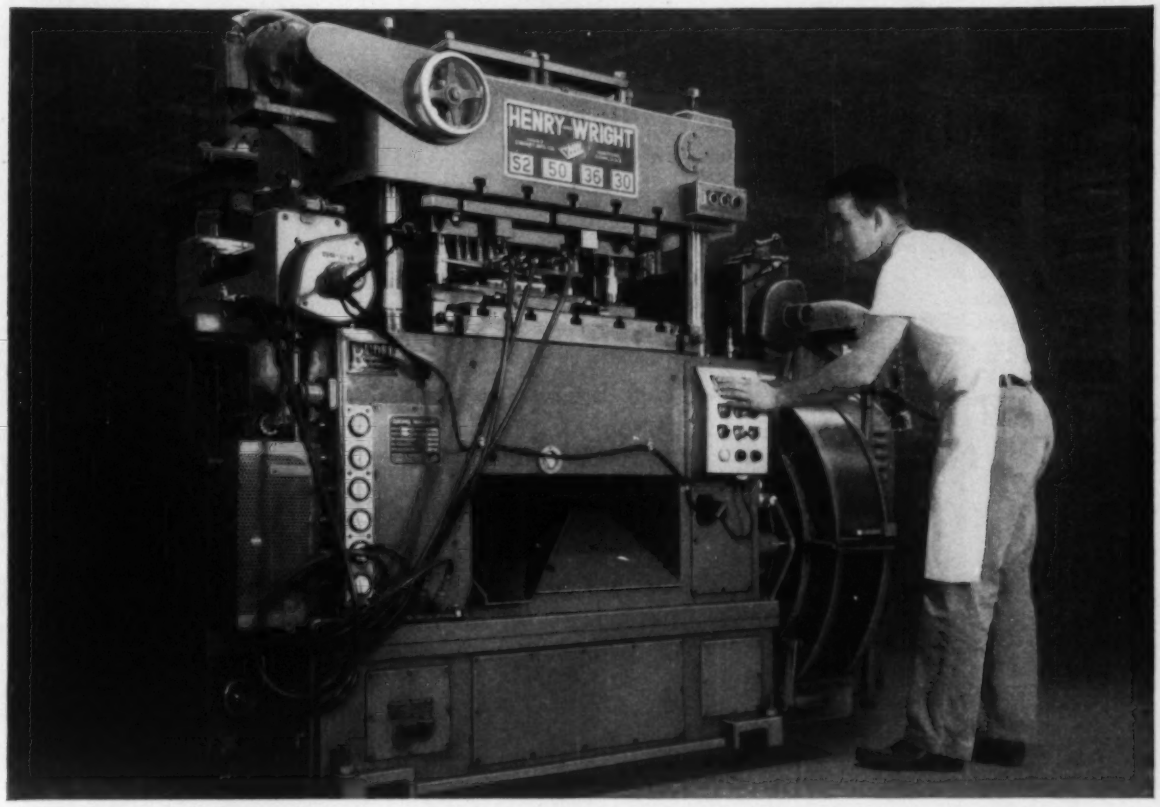
Package Classifier

Item 422

Model 9450 is designed for check-weighing small prefilled packages of material for underweight, overweight, or both. An electronic weight sensing mechanism set to a predetermined weight assures that all units accepted are within the specified tolerance requirements. Items to be classified move onto the scale approach section by means of an automatic conveyor. The item then moves over the weighing section by means of a motor driven belt. A limit switch mounted in the weighing section actuates the electronic balancing mechanism as the item moves along. The item then moves onto the take away section where a diverting gate automatically drops rejected units out of the line.

An *over-under* zero indicator provides a visual check of the weight of the items passing over the classifier in relation to the de-

Another Outstanding Henry and Wright Installation . . .



Henry & Wright 50-ton Double Crank at Electric Typewriter Division, International Business Machines Corporation, Kingston, N. Y.

IBM took these steps to assure quality stamping methods

Assure quality and reduce problems inherent in separate operations by using progressive dies for key components . . . design dies so as to accommodate sub-dies for variations in a part's configuration . . . build each die to the highest standards of precision . . . use presses of exceptional accuracy to assure maximum die life.

Double Crank Henry & Wrights were selected for this program. The pay-off: 180,000 type bars produced between die grinds as against half that number with old dies on conventional press; 8,000 trip levers per hour on a Henry & Wright against 5,000 per hour by the previous method.

Operational benefits cited by IBM personnel included: after a year's use, Henry & Wrights retained parallelism-alignment within .0005"; front and back accessibility of machines reduces die set-up time; misfeeding of stock eliminated; feed length variation is negligible, thereby making adjustments unnecessary to compensate for changes in press speed; punch clamping is easier.

To be sure of the maximum pay-off for improved methods in your plant, investigate Henry & Wrights. Catalogs are yours for the asking.

Now, more than ever before, there's an H-P-M for your particular job. Write today for complete information. Make H-P-M your standard for metalworking press equipment.

HPM

H802

THE HYDRAULIC PRESS MFG. COMPANY

A DIVISION OF KOEHRING COMPANY • MOUNT GILEAD, OHIO, U.S.A.

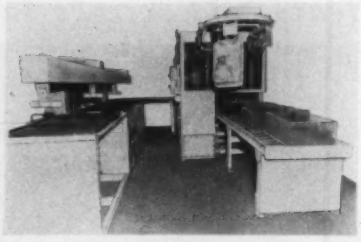
sired weight. The tolerance range, when changing from one package weight to another, is adjustable. **Toledo Scale Co.**, Toledo 13, Ohio

Circle 422 on Page 17

Parts Cleaning Unit

Item 423

Machine is designed for washing tote boxes and small metal parts of various shapes and dimensions. Small parts, loaded in baskets, are washed and rinsed using vertical



agitation in the two stage Aja-Lif automatic section of the equipment at the rate of 25 baskets per hour. Power spray washing is combined with dip-immersion-agitation for thorough cleaning of tote boxes and basketed parts. The up and down movement of the parts in the solution scrubs and shears the soils from interior and exterior surfaces of the parts.

The basketed parts are automatically transferred from point of loading through the wash and rinse stages to the unloading station. The immersion and agitating period in the wash and rinse stages is controlled by an adjustable timer. Tote boxes are washed in the power spray washing section of the machine. After transferring the small parts from the tote boxes to baskets, the operator hangs the dirty tote box on a hook of an overhead conveyor which carries the tote box through the tunnel of the machine, where it is thoroughly washed by high pressure sprays. The washing operation functions only when a tote box is passing through the spray chamber. Contact of the tote box with a control arm energizes the spray cleaning mechanism. **Equipment Div., Magnus Chemical Co. Inc.**, Garwood, N. J.

Circle 423 on Page 17

GEM-17 DIAL INDEX TABLE

TRUE GENEVA MOTION

FOR FAST, *ACCURATE* AUTOMATION OF ASSEMBLY *and* MACHINING OPERATIONS

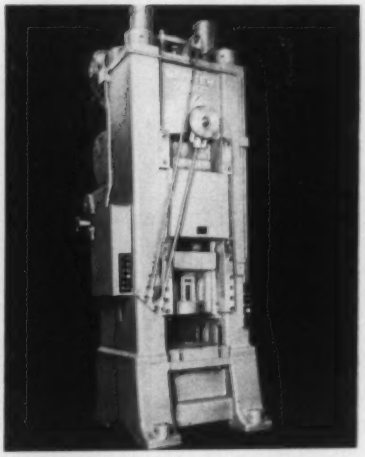
This new, high precision index table is accurate to plus or minus 0.001 in. on a 13 in. dia. work circle; can position work in as little as ½ sec.; indexes a 1,000 lb. fixture load.

BASIC SPECIFICATIONS: Standard Number of Stations—6, 8 or 12; 3 and 4 skip. Motor—Rotary air, fluid, or electric. Dial Plate—17 in. dia. standard; larger plates available. Rotation—Either direction. Interlock—Limit switch operated directly off locking bolt. Weight—200 lbs.

Gray engineers will help you adapt GEM-17 to your use. For recommendations, send specifications of your application. Illustrated brochure GE-21 and prices on request.

GRAY EQUIPMENT COMPANY

13600 Ford Road • Dearborn, Michigan • Telephone: TIffany 6-7573



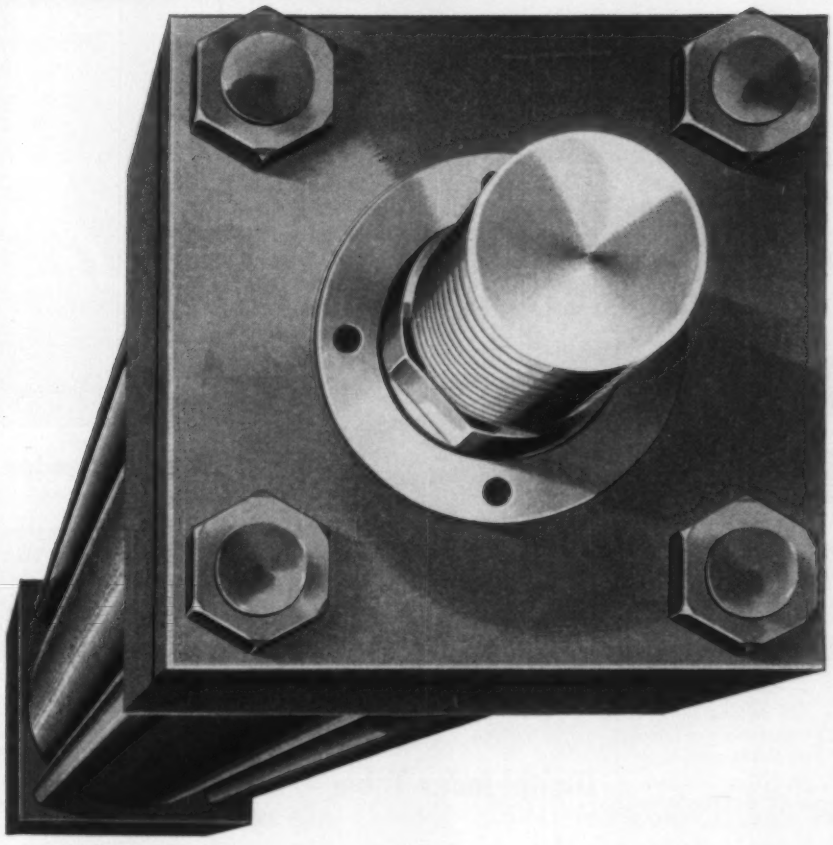
Knuckle Joint Presses

Item 424

Machine is capable of mass production coining, sizing, and embossing operations. Precision construction of knuckle assembly, adjusting wedge, frame members, slide and gibs improves accuracy of parts and promotes longer press life. The clutch and brake ar-

Circle 683 on Page 17

AT YOUR REQUEST...



ANKER-HOLTH

Hydraulic Cylinders now available in Square Head design

Positive Trouble-free Performance

Anker-Holth Division, for 18 years designers and manufacturers of quality air and hydraulic power cylinders, now offers a standard line of all steel, high pressure square head tie rod cylinders. Important new operating features and design achievements assure positive controlled power for a wide range of industrial applications.

Standardized Mountings for Interchangeability

Conservatively rated at 2000 P.S.I. working pressure and 3000 P.S.I. non-shock pressure every cylinder is proof tested at 4500 P.S.I. All mountings are available, standard bores from 1½ to 8 inches. Standardized mountings provide complete interchangeability with most makes of square head cylinders. The Anker-Holth "□" line meets all J.I.C. specifications.

For more information contact your local Anker-Holth representative or Anker-Holth Division, Port Huron, Michigan. YUkon 5-7181

ANKER-HOLTH DIVISION

THE WELLMAN ENGINEERING COMPANY

2724 CONNOR STREET, PORT HURON, MICH., U. S. A.

Circle 684 on Page 17

How

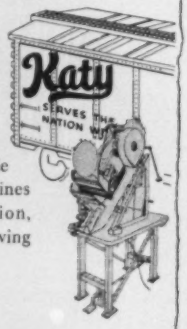
MARKEM

solves typical problems in

IDENTIFICATION and DECORATION

marking model railroad cars

Several leading U. S. toy makers had used decals (costly both to buy and apply) on their replica model train cars. Authentic imprints are now made by Markem 25A machines—speeding production, lowering costs, improving looks.

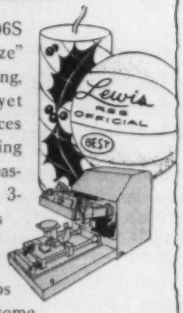


imprinting food container lids

Bothered by the cost, delivery and inventory problems caused by short run lid printing jobs done "outside", a food retailer now prints the lids he needs as he needs them, using several 45ABE machines. Supply now matches demand, with the right marking method.

screen process printing: basketballs . . . to candles

Markem 90S and 106S machines "mechanize" screen process printing, giving fine detail yet heavy coverage. Surfaces and shapes now being marked range from basketballs, candles and 3-color instrument dials to play shoes, plastic bottles and billfolds. Excellent for many jobs—the *only* method for some.



These are typical of the thousands of marking problems Markem solves every year for all types of industries. The benefits of 46 years of experience are applied to every job—and can be to yours. Write Markem Machine Company, Keene 37, N. H.

MARKEM

Circle 685 on Page 17

rangement on the crankshaft within the main drive gear allows higher single-cycle efficiency. As a result of the clutch location, higher press speeds give greater velocity at impact and tend to increase the flow of metal in cavity-type dies or sizing operations.

Recirculating oil lubrication system supplies oil under pressure to replenish oil film on the wear surfaces after every stroke. A lock arrangement prevents a change in slide adjustment and eliminates excessive tonnages, incorrect parts dimensions, and machine damage due to this cause. **Minster Machine Co.,** Minster, Ohio.

Circle 424 on Page 17

Digital Index Table

Item 425

Unit suitable for machining operations such as drilling, milling, boring, and broaching. Table can be pushbutton or punched tape programmed, and is motivated by either hydraulic or electric drives. The digital electronic control of a mechanical index mechanism permits infinite resolution from 1 to 21,600 divisions of a circle. Repetitive indices are accurate to within one second of arc.

Machine has a solid mechanical lock with zero backlash which automatically engages all index positions, is available in 18, 24, 36 and 45 inch diameters. Compensation for size change of the workpiece due to fabrication or thermal conditions during manufacture, is made by the block indexing control feature or through the flexibility of the positioning system. Table can be adjusted to high speed for minimum index time and to a variable creep or jog speed which is provided for setup purposes and shockless lock-up. **Modern Engineering Service Co.,** 1695 Twelve Mile Rd., Berkley, Mich.

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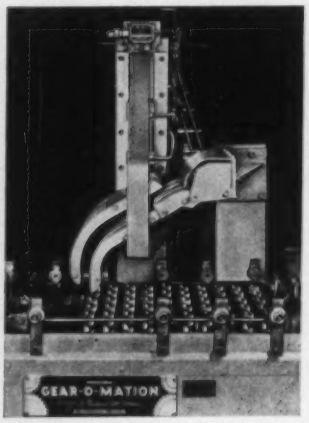

Basket Loader

Item 426

A feeding mechanism developed for automatic basketing of parts prior to, during, or after processing, has been extended to basket load long pinions. In operation, parts are fed to a dropping mechanism through an enclosed track using chain lifts and gravity flow. Rate of feed is variable through standard interlocked limit switches. Leaving the incoming track, five rolling parts are guided and tipped through curved channeled tracks and gravity fed onto upright basket prongs a row at a time. Parts release is controlled by tilting the curved tracks so that the parts can slide. A hydraulic cylinder, interlocked with the basket index, moves the feeding tracks from the *stop* to the *feed* angle.

Empty baskets enter the basket loader on a chain conveyor and are horizontally positioned by spring clips. A roller-guide retainment locks the vertical position of the basket. Indexing of the basket is done by limit switches triggered by the chain drive. The baskets stop at the loading station. As each row of prongs in the basket is loaded, the next row of prongs is automatically indexed into place. Loaded baskets are shunted over gravity rollers and conveyor chains to the next operation. **Gear-O-Mation Div., Michigan Tool Co.,** 7173 E. McNichols Rd., Detroit 12, Mich.

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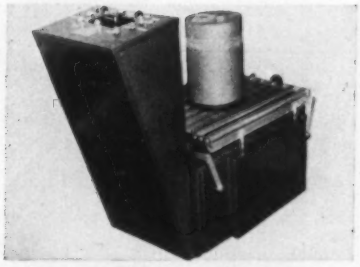


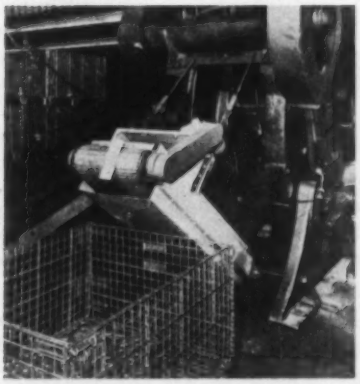
Check Weighing Scale

Item 427

Instrument suitable for production weighing in packaging or batching operations. Heart of the scale is the Thayer Flexure Plate Leverage System which functions without the use of knife-edge pivots. Exact weight is indicated by a direct reading register in the decimal system either in pounds or grams. The scale can also be used for classifying and segregating weight groups if desired.

Scale is available in various capacities and can be furnished with a ticket printer, chart recorder, remote weight indicators, fully automatic conveyor systems for complete automatic control, and other optional features to suit any specific installation requirements. Platform sizes can also be constructed to suit the item to be weighed. **Thayer Scale Corp.,** Thayer Park, Pembroke, Mass.

Circle 427 on Page 17

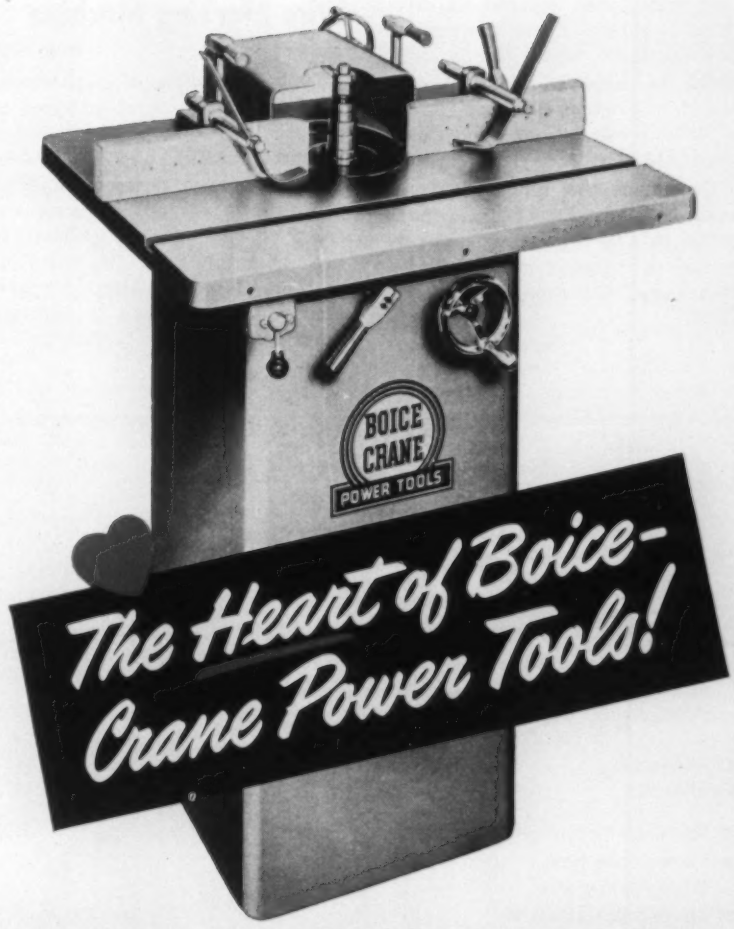


Conveyor Unit

Item 428

Suitable for handling stampings, forgings, castings and small parts, conveyor is offered in three belt widths: 8, 12 and 16 inches.

The drive unit of the Series P Versa-Veyor is powered by gear-



BALDOR STREAMCOOLED MOTORS

For years famous Boice-Crane Power Tools have enjoyed a reputation for faultless performance. And for years, like hundreds of other leading manufacturers, Boice-Crane has specified and depended on Baldor Streamcooled Motors to maintain its enviable prestige.

If customers demand this kind of superior performance from *your* equipment, it will pay you to consult Baldor. Experienced engineers are available to help take the kinks out of all your knotty motor problems . . . *without obligation!*

Rear view of Boice-Crane Spindle Shaper showing vertical installation of Baldor Streamcooled Motor.

Write for Catalogs on Complete Line!

Baldor ELECTRIC CO.

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Circle 686 on Page 17

head motor with roller chain drive to head pulley. Drive components are enclosed with guards, belt speed is 60 fpm, bearings are sealed. Crowned end pulleys and adjustable end bearings allow easy alignment.

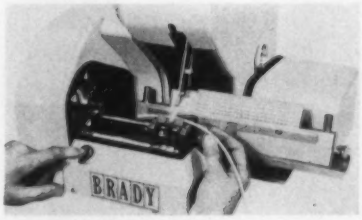
Design of the unit provides a range of adjustment from horizontal to a 60-degree angle and remains in balance at all angles. **Belt Corp.**, 810 Stahl Rd., Orient, Ohio.

Circle 428 on Page 17

Wire Marking Machine

Item 429

Unit is capable of high speed production marking of all types of electrical wire. Wires can be coded by number, letter, or symbol—consecutively, or in series of consecutive groups, without changing the speed or feed of the machine. In use, operator puts full card of markers into indexing carriage. Wire to be identified is fed into machine. Operator pushes button

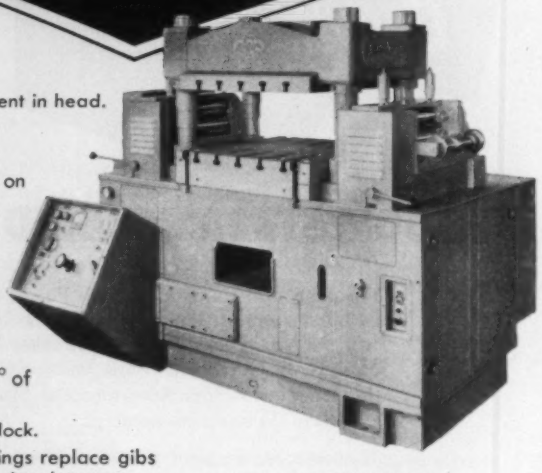


to begin automatic cycle that wraps marker completely around the wire. Marked wire is removed. All bearings are antifriction.

Coils or pre-cut pieces of wire for leads, harnesses, or bridges can be fed into the machine. Wire on which terminals have already been fastened or wires with or without insulation can be marked interchangeably. Markermatic can also handle most cylindrical or oblong shapes such as capacitors, and resistors. **W. H. Brady Co.**, 727 W. Glendale Ave., Milwaukee 9, Wis.

Circle 429 on Page 17

ALPHA
TWO POINT
BACK GEAR UNDER DRIVE
PRODUCTION PRESSES
Capacity of 75 to 200 tons



Outstanding Features

- Shut height adjustment in head.
- Center drive type herringbone gears.
- Scrap cutter action on up-stroke of press.
- Cam adjustments for brake & roll feeds.
- Micro adjustment of metal travel.
- Timing of scrap cutter from 0° to 45° of up-stroke of press.
- Positive shut height lock.
- Bronze sleeve bearings replace gibs as utilized on conventional presses.

These precision presses are basically precision operating, high-speed automatic stamping presses. They have built-in precision in the same terms as the word "precision" is associated with modern machine tools. This inherent quality has been designed into these presses from the ground up.

NO PITS REQUIRED.

UNBALANCED DIES can be handled without distortion.

FAST, ACCURATE, WILL GIVE LONG TROUBLE-FREE SERVICE and LONG DIE LIFE.

PRESSES UP TO 300 TON CAPACITY, AVAILABLE TO CUSTOMER PARTICULAR REQUIREMENTS.

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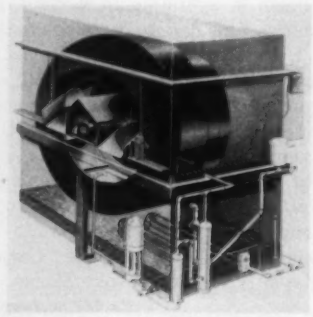
ALPHA PRESS & MACHINE, INC.

9281 Freeland Avenue • Detroit 28, Michigan



Automatic Degreaser

Item 430

Rotary drum degreaser provides thorough cleaning of such products as nuts, bolts, fasteners, stampings, and screw machine parts. Model 1DD750 does in-process cleaning, cleaning before heat treatment, cleaning before plating, phosphatizing, bright dipping, and final cleaning. It handles 5 cu ft per hr, with a rated capacity of 2000 lb steel or brass per hour. Parts to be cleaned enter through a conventional chute, are carried through the degreaser by a screw-type drum which tumbles the parts, subjecting them to vapor and immersion cleaning and final vapor rinse and drying. Parts are then discharged through a chute on the opposite side. **Detrex Chemical Industries Inc.**, Box 501, Roosevelt Park Annex, Detroit, Mich.

Circle 430 on Page 17

MANSFIELD, OHIO, KNOWS *CCC

Yes, Mansfield is well aware of Commercial Contracting Corporation's team of specialists. That's the town where CCC installed the presses and machine tools in the nation's largest stamping plant. These heavy presses are turning out body stampings for America's major builder of motor cars.

CCC won the job through experience in installing automated equipment . . . for world leaders in the production of steel, aluminum and automobiles.

Industrialists all across America know that CCC is prominent in important plant installations of the post-war expansion era. They rely on the talents and techniques, the experienced supervision and precise organizing that CCC brings to every job. If your company is planning the removal, relocation or installation of machinery, turn the job over to CCC. Your project will be completed *quickly, economically* and *efficiently*.

CCC services, individually or under one Package Contract, include: Press Erecting • Rolling Mill Installation • Machinery Installation and Moving • Foundry Installations • Overhead Crane Installation • Mothballing.

Write for new illustrated brochure.

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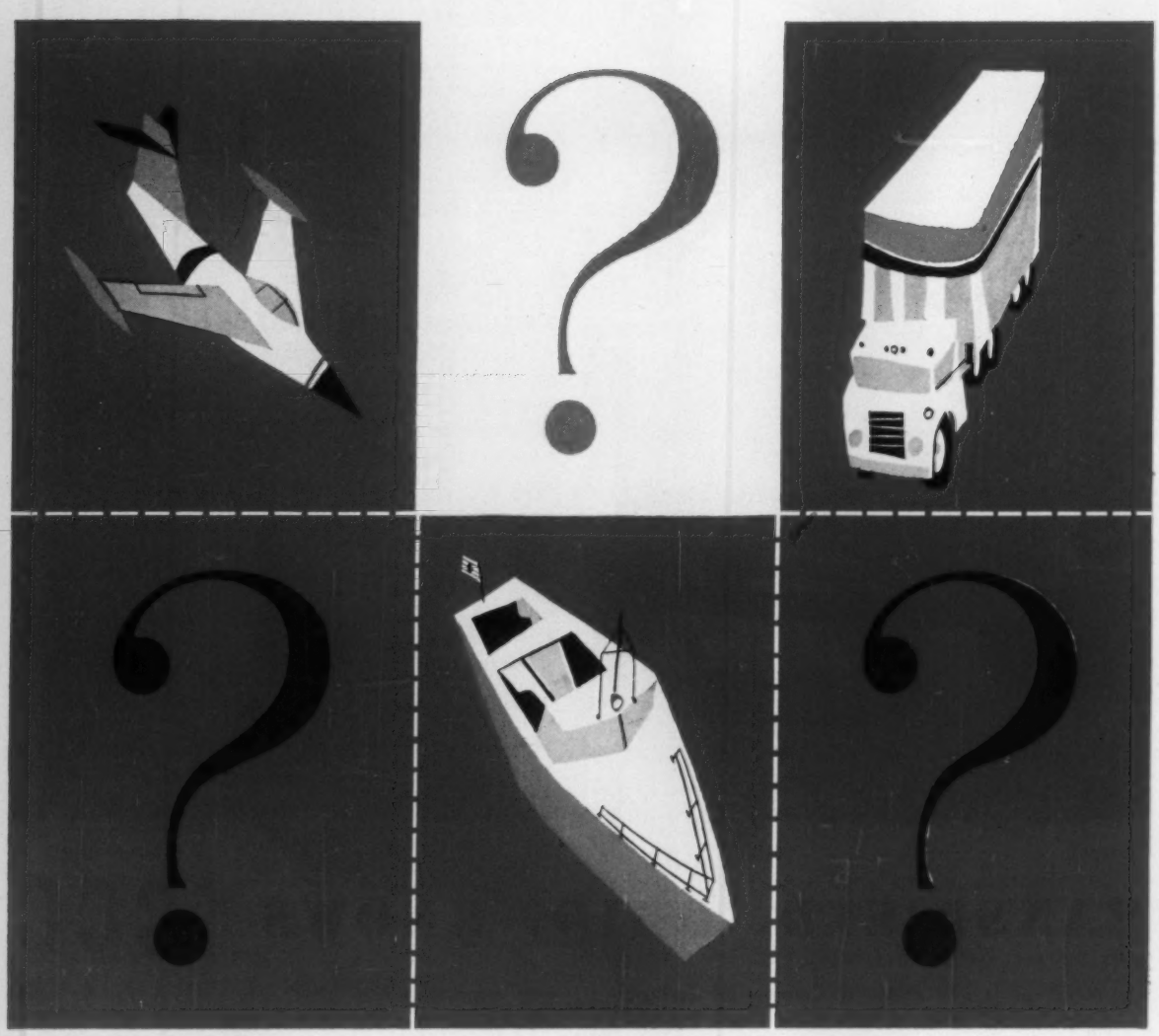
Circle 688 on Page 17

Can you use . . .

switches triggered by speed



AC engineers have developed speed sensing switches so accurate that they operate . . . and continue to operate . . . within limits of .5% . . . This is the most sensitive speed switch yet produced . . . and the most accurate method of synchronizing up to four critical turbine engine functions with pre-selected RPM. Current applications bear out this accuracy and sensitivity over switching ranges from 500 to 4600 RPM. Newly developed models are effecting a dramatic increase in range. The AC Speed Sensing Control is lightweight, weighing less than four pounds. It withstands high engine vibration. It will hold calibration and operate without attention for periods longer than those recommended for jet engine overhauls. For more information about automatic control of speed-related electrical switching operations, give AC's Milwaukee group a call. *If you are an electrical or mechanical engineer and feel you might like to work with AC in Milwaukee, write Mr. Cecil Sundeen, Supervisor of Technical Employment, in care of . . .*

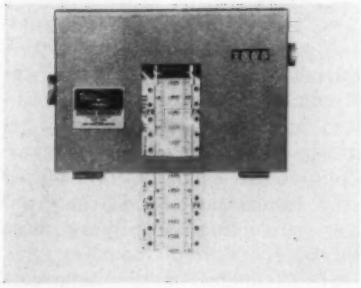
AC . . . THE ELECTRONICS DIVISION OF GENERAL MOTORS, MILWAUKEE 1, WISCONSIN

Afterburner Fuel Controls • Bombing Navigational Computers • Emergency Fuel Controls • Gun-Bomb-Rocket Sights • Gyro-Accelerometers • Gyroscopes Inertial Guidance Systems • Manifold Air Pressure Regulators • Speed Sensitive Switches • Speed Sensors • Three-Way Selector Valves • Torquemeters

AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems

For detailed information and literature, use card page 17.



Print-Out Counter

Item 431

Instrument is adaptable for monitoring any production machinery, conveyor belt flow, office machines, cash registers, printing equipment, and automotive traffic. It gives accurate print-out, at predetermined intervals, of elapsed time or number of units produced. Unit is electrically connected to the machine or process to be monitored. A chronologically-marked chart roll is sprocket driven through the instrument. At predetermined intervals, the total elapsed time or the total number of units monitored in that interval is printed on the tape. A visual cumulative total is provided for longer periods.

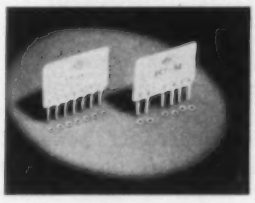
Data provided by the counter can furnish a basis for pinpointing production bottlenecks, analyzing tools, methods, and personnel, accurate cost-accounting, and preventive maintenance. Counter is available in four different models, in 5-digit or 4-digit printers. Standard print-out intervals are 5, 15, 30, or 60 minutes. Chart roll tapes for unit are 250 feet long, require no ink, and are available in varied speeds from 1 inch per hr to 12 inches per hr. **Standard Instrument Corp.**, 657 Broadway, New York 12, N. Y.

Circle 431 on Page 17

Narrow Tab Terminals

Item 432

Designed for automatic insertion, terminals are suitable for use with printed or etched board circuitry. Terminals are constructed



for easy plug-in to 0.055-inch holes with perfect alignment of terminals on 0.172-inch centers. Units are available in company's basic plate sizes. **Centralab, div. of Globe-Union Inc.**, 900 E. Keefe Ave., Milwaukee, Wis.

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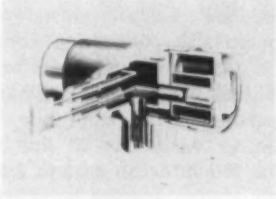


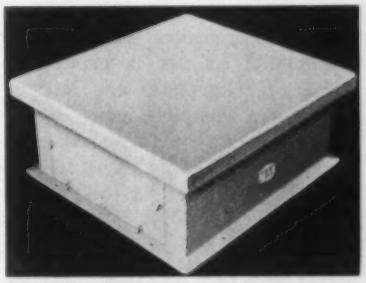
Level Detector

Item 433

Unit is designed for high or low point detection, or narrow range proportional control of liquid, solid and slurry levels. A positive acting electrical output control signal varies with the amount of immersion of the 120 cps vibrating paddle in the medium being detected. The output signal can be used to control the operation of any type of electrical equipment.

Design allows sensitive transmission of vibrational energy from the driver end to the sensing paddle and back to the output signal end through a linkage path welded to rigid metal pressure seals at the node points where zero amplitude of vibration occurs. Unit is explosion proof and rated for 3000 psig pressure, 115v ac. **Automation Products Inc.**, 3030 Max Roy St., Houston 24, Tex.

Circle 433 on Page 17



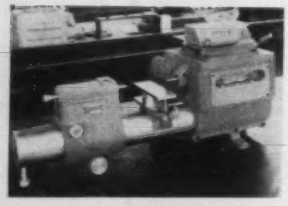
Vibrating Packers

Item 434

Device is capable of fast, uniform settling and compacting of materials in boxes, bags, drums, and other containers to facilitate packing, sealing, and filling with full count and weight. Packers are self-contained units complete with motor driven reciprocating unit producing ⅛ to 3/16-inch strokes at 1200 cycles per minute. Model 50 can handle container capacity up to 350 lb, has ⅓-hp

drive. Model 60 can handle container capacity up to 500 lb, has ½-hp drive. **Ajax Flexible Coupling Co. Inc.**, Westfield, N. Y.

Circle 434 on Page 17



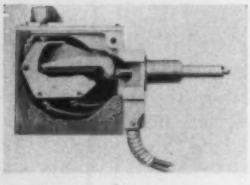
Recording Micrometer

Item 435

Gage is designed for fast, accurate, direct measuring of reamers, end mills, plug gages, and similar products. Readings directly to hundred thousandths of an inch are automatically made and recorded. A printed record is made of every measurement taken. In use, the operator places his work between the spindles and presses a switch. The switch energizes a motor, advancing the headstock spindle to the work. When a known gaging pressure on the tailstock spindle has been reached, the motor is automatically switched *off* and a brake applied.

When the measurement has been established, a red light signals the operator. He inserts a card in the slot and depresses the readout lever. The dimension shown on the illuminated counter is printed on the card. The meter can be supplied as a complete unit, or the headstock can be furnished as a packaged unit and placed directly on the bed of an existing Supermicrometer. **Pratt & Whitney Co. Inc.**, Charter Oak Blvd., W. Hartford, Conn.

Circle 435 on Page 17



Thermostat

Item 436

Instrument was developed for use where sensitivity is required to a temperature change as low as a fraction of a degree. It is constructed to withstand extreme temperatures above or below the calibrated range. Thermal element is composed of two metallic members, a metal tube with a high rate of expansion and a steel rod with a low rate of expansion. These members are connected with the proper leverage to operate a snap-acting switch. Adjustment of temperature setting is done by turning a knob to the desired degree within the calibrated range. Switch is rated at 15 amps, 125v, ac. **Alloy Bellows Inc.**, 18125 Roseland Rd., Cleveland 12, Ohio

Circle 436 on Page 17

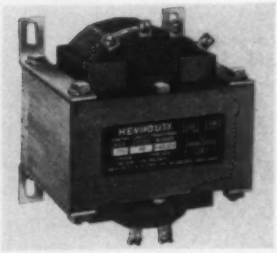
Voltage Regulator

Item 437

Designed for industrial or laboratory use in the control of power line voltage variations, Model 601 is independent of power factor, making its application unrestricted. It is useful in areas where line voltage is subject to wide fluctuations. Output voltage is adjustable by means of a front panel control over a range of ±10 per cent of 115v. The output can be regulated if the input voltage remains within ±10 per cent of the output at rated capacity of 3.6 kva.

Voltage correction is possible through the use of a hard tube closed-loop servo system which automatically controls a continuously adjustable autotransformer. Amplified error voltage which is proportional in amplitude and phase to variations in line voltage is fed into the system from a highly stable tungsten lamp bridge. Replaceable plug-in control circuit, front panel voltmeter, and a combined circuit breaker and line switch are features of the unit. **Tel-Instrument Electronics Corp.**, Dept. T, 728 Garden St., Carlstadt, N. J.

Circle 437 on Page 17

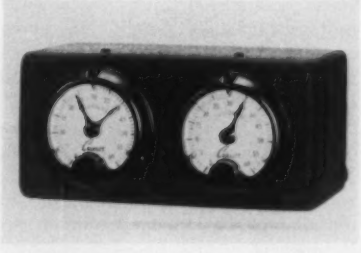


Dry Type Transformers

Item 438

Units available in standard sizes from 0.050 to 5 kva are designed and constructed for long, dependable service under rugged operating conditions. A high insulation level is provided by folded insulating papers between the layers, varnished cambric between the windings, a preformed coil base, and heavy insulating channels between core and coil. These transformers can handle up to 1000 per cent inrush current with only a 5 per cent voltage drop below rated capacity. Slotted mounting feet and a diagrammatic nameplate simplify installation. **Hevi-Duty Electric Co.**, 2040 W. Wisconsin Ave., Milwaukee 1, Wis.

Circle 438 on Page 17



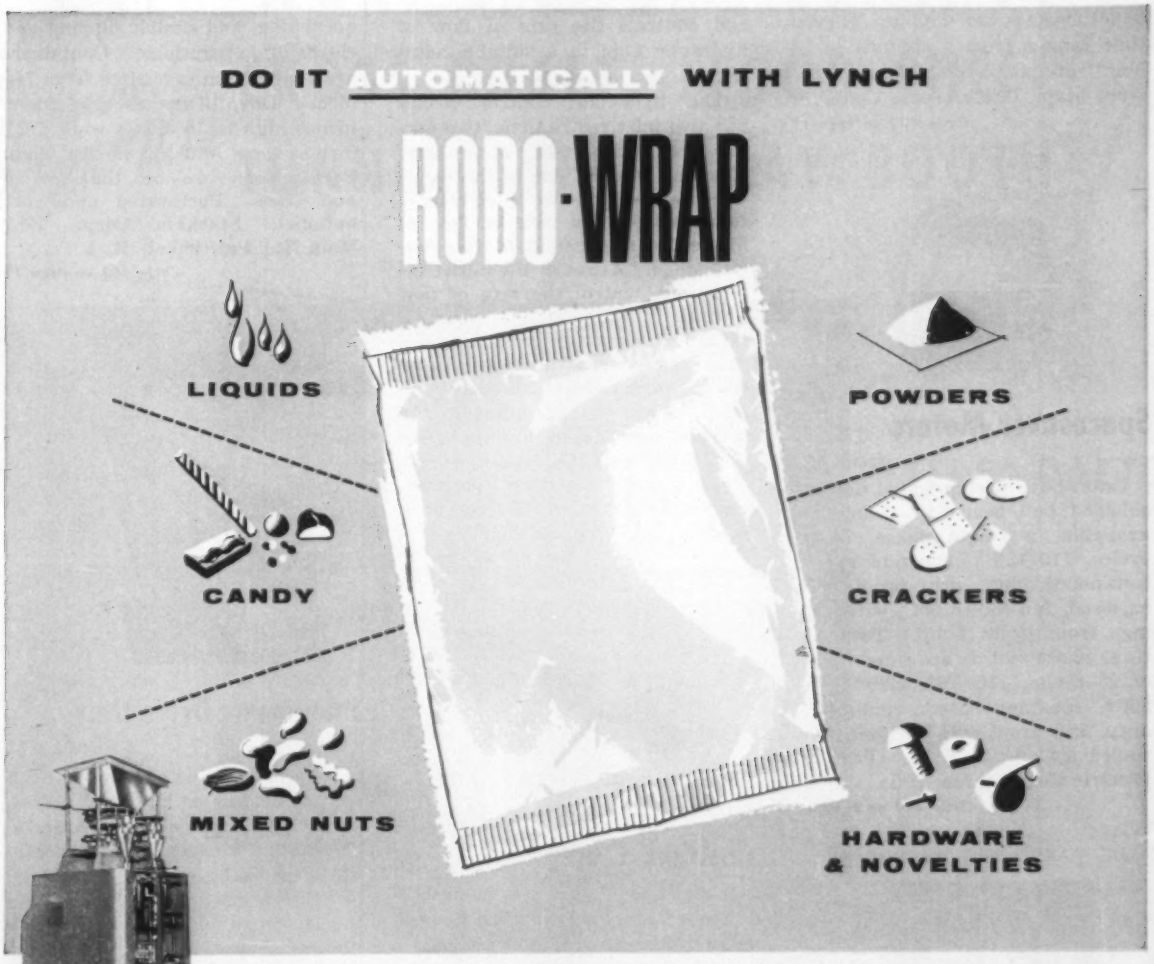
Duplex Cycling Timer

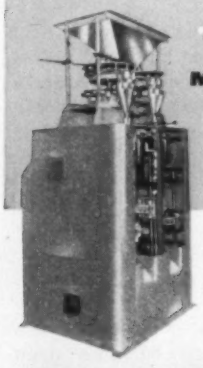
Item 439

Unit can control the operation of process work equipment and regulate both idle and operating time on a wide variety of production machinery. After the initial starting circuit is closed, timer in the unit operates in turn providing a timed interval or delay, restarting the other at the conclusion of each timed period, and then resetting for the next cycle. Load switch is operated within a repeat accuracy or ¼ per cent of the full scale reading. Model 742 is rated for operation on 115v or 220v, 60

DO IT AUTOMATICALLY WITH LYNCH

ROBO-WRAP





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LYNCH ROBO CORPORATION
A Division of
LYNCH CORPORATION
Anderson, Indiana

Circle 690 on Page 17

or 50 cycle power supplies. Eleven time ranges from 6 seconds to 24 hours are available. **Cramer Controls Corp.**, Centerbrook, Conn.

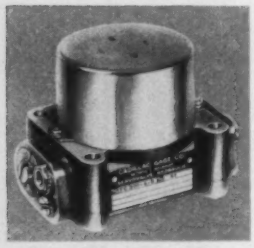
Circle 439 on Page 17

Spacesaver Motors

Item 440

Units have prelubricated double-shielded ball bearings. They are available in single phase, 50/60 cycles, 115/130 v, constant speed, continuous duty, drip proof 50C, enclosed, fan-cooled 55C, with ratings from ½ to 3 hp. Two and three phase motors are rated 50/60 or 20 cycles, 110, 208, 220/440 or 550v, constant speed, continuous duty, drip proof 40C, enclosed fan-cooled 55C, ½ to 5 hp. **Peerless Electric Co.**, Warren, Ohio.

Circle 440 on Page 17



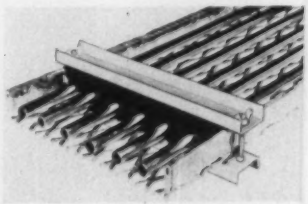
Electrohydraulic Valve

Item 441

Unit is capable of functioning reliably under rigorous operating and ambient conditions. Valve has a minimum of moving parts, no springs, and incorporates a single large capacity filter element to protect the control stage. The valve is of two-stage construction. The control stage includes an electro-mechanical transducer and a closed *push-pull* hydraulic control circuit which positions the second stage in response to electrical input signals to the valve. The output stage consists of an accurately matched spool and sleeve which form a precision four-way valve, and controls the rate of flow of hydraulic fluid to a suitable actuator.

The hydraulic control circuit has two inlet restrictions, two outlet restrictions, and a pressure chamber on each side of the valve. The areas of the two inlet restrictions control the rate of flow of filtered pressure fluid to the control stage. Areas of the outlet restrictions control the rate of flow of fluid from the amplifier to drain. With the armature in its centered position the areas of the two outlet and inlet restrictions are equal. As a result, the pressures in the chambers on each end of the spool are equal and the spool is restrained in its center position. **Cadillac Gage Co.**, 25760 Groesbeck Highway, Detroit, Mich.

Circle 441 on Page 17

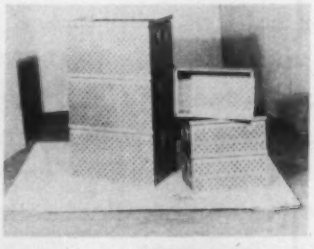


Cushion Clamp

Item 442

Device is used to secure instrument tubing to the tubing support trough when particular care must be taken to minimize vibration. Clamp uses two pieces of sponge neoprene with nitrogen filled voids to prevent moisture absorption. Two wing nuts draw the clamp tightly into place over the pieces of tubing. **T. J. Cope Div., Rome Cable Corp.**, Collegeville, Pa.

Circle 442 on Page 17

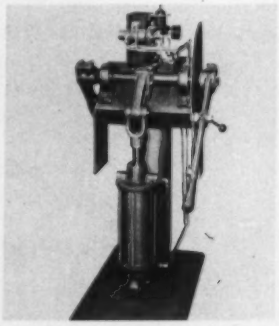


Perforated Stackboxes

Item 443

Units are suitable as containers for vapor or liquid degreasing, quenching, and similar dipping and cleansing operations. Containers are available in four sizes from 7½ inches wide, 13 inches long and 6 inches high to 15 inches wide, 19¼ inches long and 11 inches high. Perforations are on the bottom and sides. Perforated ends are optional. **Stackbin Corp.**, 1287 Main St., Pawtucket, R. I.

Circle 443 on Page 17



Pneumatic Drive Unit

Item 444

Item is designed to position such control devices as butterfly valves, control valves, dampers, louvers, rheostats, vanes, and variable-speed drives by remote, automatic, or manual pneumatic signals having a range of 0-20 psig. Drive unit consists of a positioner, four-way valve, power piston, and feedback cam. In the pneumatic circuit, the positioner supplies air pressure to operate the four-way valve, which is in balance when feedback position balances pneumatic demand. Positioner output is stabilized at approximately 9 psig, null-balance point of the valve.

Any plus-or-minus deviation from 9 psig determines both magnitude and direction of drive-unit movement by exhausting one side of the power piston and increasing air loading on the other side. In the manual position, an integral transfer valve shuts off the main air supply to both the valve and positioner, and exhausts both sides of the power piston. The torque shaft can be directly positioned by a lever or handwheel for easy accessibility to the pneumatic parts. Optional accessories available are mechanical or pneumatic stops, limit switches, position indicator,

Circle 691 on Page 17→

OVER-SPRAY and FUME CONTROL

Assured With This CROSS DRAFT, FLOOD SHEET TUNNEL TYPE SPRAY BOOTH

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TUNNEL TYPE SPRAY BOOTH—BUILT AND INSTALLED BY PETERS-DALTON—NOW IN SERVICE AT THE NEW LINCOLN DIVISION PLANT, WIXOM, MICH.

Loss of time and impairment of working conditions is eliminated in finishing operations with an installation by P-D such as illustrated above . While the tunnel type booth shown was designed, engineered, built and installed by Peters-Dalton for a major automotive manufacturer, a comparable or smaller cross draft, floor-sheet booth may be the answer to your finishing problem. The size of your product or production run quantities may not require as large an installation. However, regardless of your needs, Peters-Dalton can design a finishing system to best and most efficiently meet your production finishing requirements.

Peters-Dalton offers more than a quarter century of designing, engineering and building finishing systems of all sizes and types. Low initial cost and economical production runs can be yours with an installation by P-D. Why not send us your specifications or prints? Just write, wire or phone . . . we'll be glad to tell you more.

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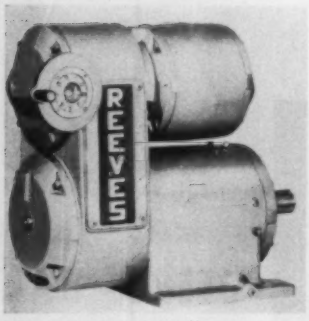
position transmitter, connecting linkage, and automatic air lock with automatic or manual release. **Copes-Vulcan Div., Blaw-Knox Co.,** Erie, Pa.

Circle 444 on Page 17

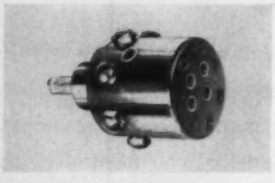


Variable Speed Drives

Item 445

Units are applicable for installations requiring 1 through 5 hp. Vari-Speed Motodrives are designed in two styles — *C* flow (shown) and *Z* flow. Design of the units gives a wider ratio of speed variation, more speed ranges, and increased reducer capacity. Handwheel control location can be rotated to optional positions and extra precision of control is available with company accessories. **Reeves Pulley Co., div. of Reliance Electric & Engineering Co.,** 1225 Seventh St., Columbus, Ind.

Circle 445 on Page 17



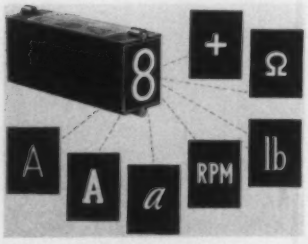
Hydraulic Pump

Item 446

Unit is a multipiston pump with the discharge manifold modified to isolate the output of one or more of the pistons from the output of the rest of the pistons. Two or more independent flow rates can thus be obtained by the use of only one pump and motor. By adapting separate relief or pressure control valves to the several independent flow rates, one pump can handle a variety of hydraulic operations.

A typical application is with the accumulator systems. When using such a system, the output from one piston of the pump is used to positively load and unload the remaining pistons of the pump, eliminating use of unloading valves. All 7 pistons of the pump deliver power to charge the accumulator up to the pressure setting of the bypass valve. One piston continues to maintain the maximum accumulator pressure after the other pistons are unloaded. Pressure is maintained and any normal system leakage is supplied by this one piston discharging over the relief valve. **Simplex Engineering Co.,** Zanesville, Ohio.

Circle 446 on Page 17



Digital Display

Item 447

In-line display features digits of varying size, shape, and color. Digits are available in any size or form, and can include foreign characters, sans-serif, or Roman faces, etc. in light, medium, or bold weights. Colors available are red, green, yellow, blue, and purple. Display can be purchased in single units and assembled in groups as required. Viewing screen extends the full width of the unit, and the final assembly of a group presents a continuous surface. Units are available from 6 to 48v ac. **Industrial Electronic Engineers,** 3973 Lankershim Blvd., North Hollywood, Calif.

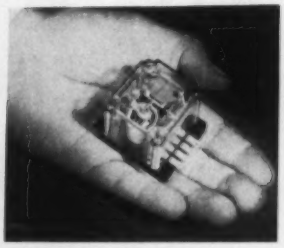
Circle 447 on Page 17

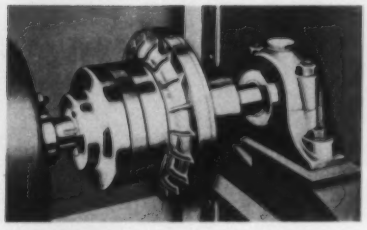
Magnetic Contact Relay

Item 448

Unit can withstand more than 500 g and vibration of 5 to 55 cps at 0.060-inch amplitude. Insulation resistance exceeds 1000 megohms. Model 281 measures approximately 2 by 1¾ by 1½ inches, and has a self-contained reset mechanism. Feature of the relay is a movement with a pointer on a coil that moves in proportion to the signal. When the signal reaches a limit preset at the factory, a gold-plated contact on the moving pointer is attracted with striking force to a fixed contact which is a small magnet. To separate the contacts, power is applied to a reset coil. This actuates two scissors-like arms that pull the pointer back to center scale. Unit is available with either single or double limits. **Assembly Products Inc.,** Chesterland, Ohio

Circle 448 on Page 17

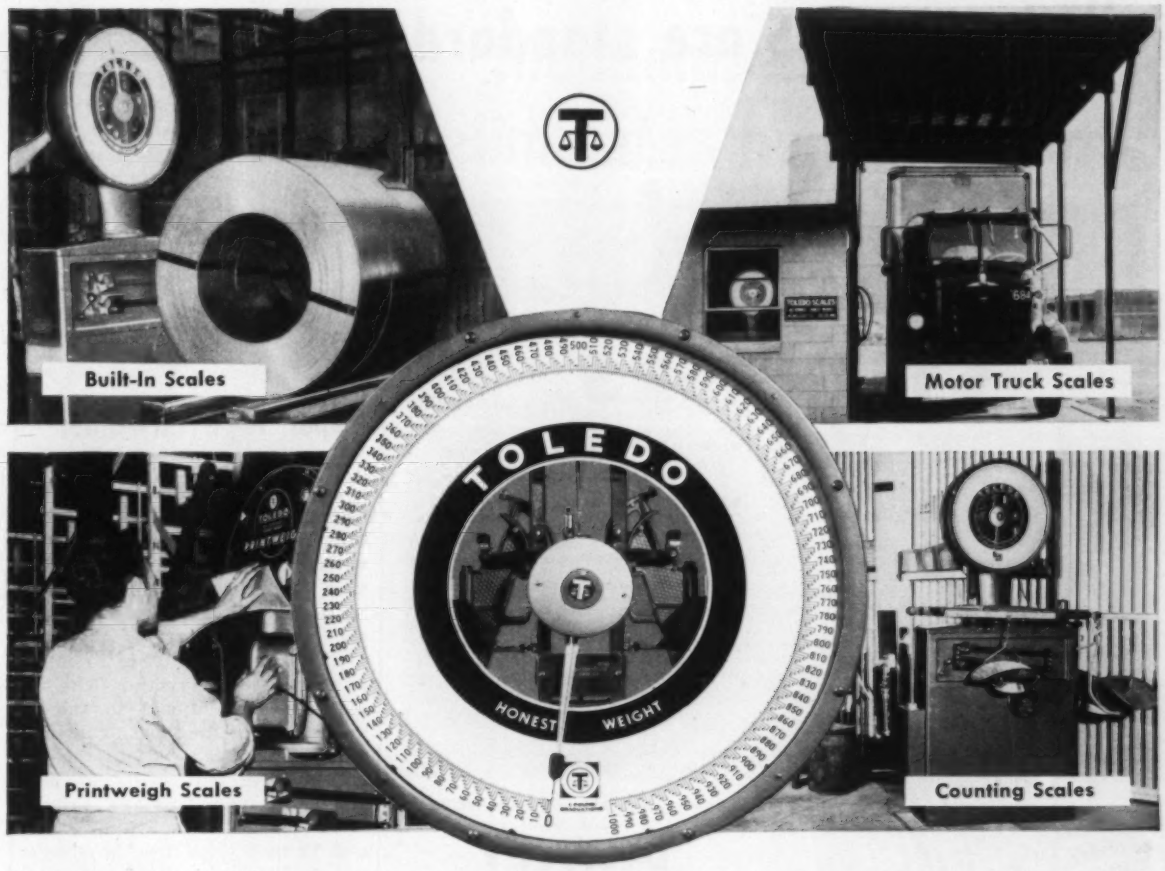




Dry Fluid Drive

Item 449

Design principle of the fluid drive provides a method to start loads smoothly, protect against shocks and overloads, and save power. The fluid in unit is heat treated steel shot. A measured amount, called the flow charge, is contained in the housing, which is keyed to the motor shaft. When the motor is started, centrifugal force throws the flow charge to the perimeter of the housing, packing it between the housing and the rotor which transmits power to the load. After a brief starting period of slippage between housing and rotor, the two become locked together and achieve full load



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What's the status of weighing in *your* plant? It's important to know because weighing is a vital element in the overall cost control system. Weight records directly affect costs, quality, inventory control and customer billing. Weighing errors—or inadequate weight data—set the stage for losses in output, profits and customer good-will.

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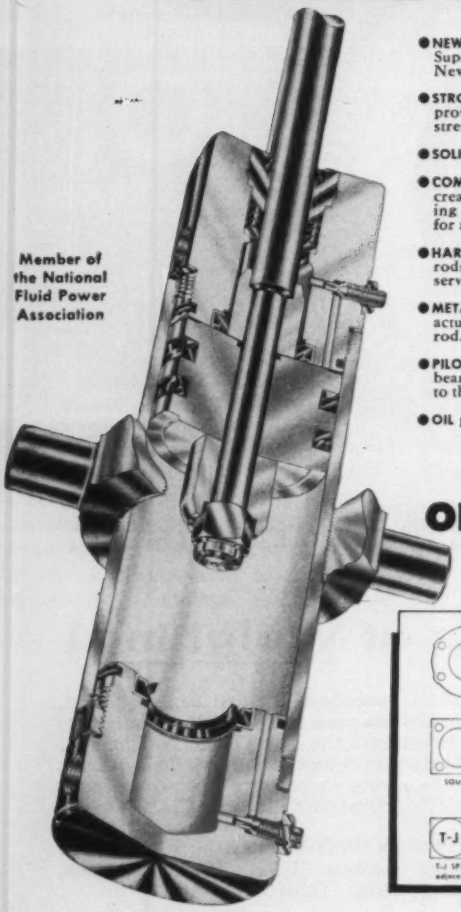

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- **NEW** *exclusive* ingenious cushion designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Cushion for Oil.
- **STRONGER** than outmoded tie rod design, proven through actual tests. No tie rods to stretch.
- **SOLID STEEL HEADS** throughout the full line.
- **COMPACT DESIGN** eliminates tie rods, increasing the strength and reducing mounting space required, providing extra room for adjacent equipment.
- **HARD CHROME PLATED** body bores and piston rods . . . assure you of long trouble-free service. (Standard at no extra cost.)
- **METALLIC ROD SCRAPER,** not just a wiper, actually removes foreign matter from the rod.
- **PILOTED PACKING GLAND** with extra long bearing. Additional strength and support to the piston rod.
- **OIL** pressure to 750 p.s.i. AIR to 200 p.s.i.

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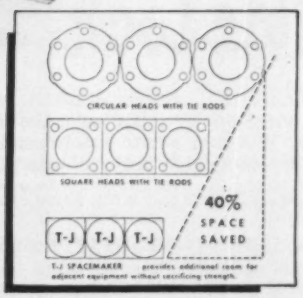


You *save 40% space* when you switch from outmoded tie rod cylinders to the T-J Spacemaker! It's stronger, too! Fits right into automation programs in countless plants. Delivers top performance and dependability with a big *plus* in advanced features. Wide range of styles, capacities . . . reduces man-hours and costs in all kinds of push-pull-lift jobs. Off-shelf delivery in 64,000 combinations!

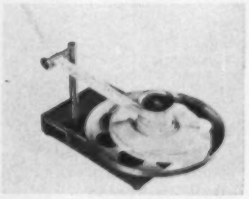
NEW LITERATURE—Send today for new Catalog SM56 with complete engineering details on Spacemaker line. Write The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVITORS . AIR AND HYDRAULIC CYLINDERS . CUTTERS . CLINCHORS

Circle 695 on Page 17

speed. Units are available for loads as high as 150 hp. **Dodge Mfg. Corp.,** Mishawaka, Ind.

Circle 449 on Page 17



Paper Tape Unwinder

Item 450

Device can feed any standard tape widths to automatic transmitters, computers, typesetters, typewriters, readers, comparators, verifiers, or business machines. An integral tape guide takes tape from the center, or start of the accumulated roll, and feeds to inputs at any angle or direction. The unit automatically adjusts to the requirements of the input. Unwinder consists of a light weight reel-pan with a centered cone that rides freely on nylon bearings. Friction is negligible. It is available in 8 and 12 inch capacities, is convertible from either size to the other. **Whiteford Laboratory,** 420 Market St., San Francisco 11, Calif.

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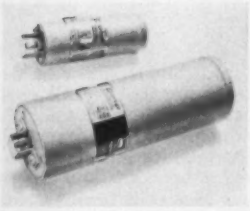


Hydraulic Accumulators

Item 451

Piston-type accumulators are adaptable for shock absorption purposes to keep pressure constant, smooth out the operation and protect the other units in the system from the damaging effects of excessive momentary peak surges of pressure. The accumulators are also useful as auxiliary or emergency sources of hydraulic power. A v-o-ring design of synthetic rubber provides long seal life and trouble-free sealing. The line in-

cludes 14 models ranging in oil capacity from 10 cu in. to 10 gal, and four inside diameter sizes ranging from 2 to 7 inches. The units can be mounted in any position. **Industrial Hydraulics Div., Parker Appliance Co.,** 17325 Euclid Ave., Cleveland 12, Ohio

Circle 451 on Page 17

Electronic Relay

Item 452

Device is suitable for use with a probe for level control in the filling of containers, for temperature or pressure control where a mercury column or Bourdon tube contacts the relay; precision measurement at the anvils of a micrometer; control of oil refining apparatus and electronic sorting equipment. Model 3003 can operate with as much as ½ megohm in series with the contacts. Relay action is initiated by an external contact connected to the input circuit and the current through the contacts is less than 10 millionths amp with 500,000 ohms contact resistance.

Input power is less than 0.00005 w and the output circuit can carry up to 600w. Relay operates from 115v, 50-60 cycle power input. Contacts are double pole, double throw with 5 amp resistive load. **Monitor Controller,** 99 Grove St., Rockland, Mass.

Circle 452 on Page 17

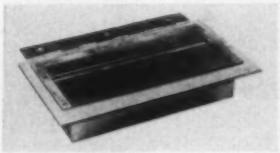
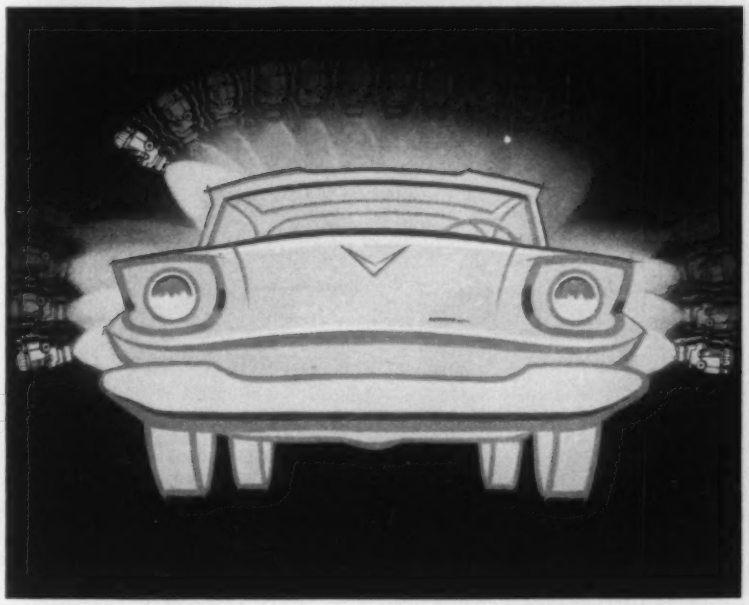


Plate Magnet

Item 453

Device is designed to remove tramp iron from flowing material

Mechanized painting eliminates human errors

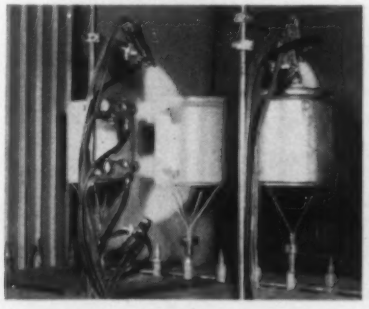


DeVilbiss Automatic Contour Spray Machines are a vital part of the finishing lines in the world's most modern plants, turning out gleaming finishes in a variety of colors at low cost.

DeVilbiss automatic spray machines consistently turn out paint jobs to perfection . . . on products of practically any size and shape. Split-second timing and accurate gun positioning cuts paint waste to a minimum, and ensures absolute uniformity of finish on every part. And these results are attained with high-volume production at remarkably low cost!

But it takes more than just ordinary spray equipment to do the flawless, cost-saving jobs that are demanded today. DeVilbiss meets this demand with experience and know-how that combine the full knowledge of materials, production methods, and spray techniques with the most versatile, efficient automatic spray equipment that's available.

Why not let us test run your product in our Customer Lab – without obligation – for a report of actual costs, plus projected savings over your present system? Our nearby representative will gladly make the arrangements.



Simultaneous painting of exterior and interior of these 5-gal. pails is typical of versatility, efficiency of DeVilbiss automatics.

THE DEVILBISS COMPANY
Toledo 1, Ohio
Santa Clara, Calif. • Barrie, Ontario
London, England
Branch Offices in Principal Cities

FOR BETTER SERVICE, BUY
DEVILBISS

DEVILBISS HELPS YOU GET THE MOST FROM THE SPRAY METHOD

Circle 696 on Page 17

in chutes, spouts, ducts, or on conveyors. An offset air gap principle concentrates the magnetic force directly over the first pole piece. Tramp iron cannot speed up as it approaches the magnet face. It enters the magnetic zone abruptly and is effectively held at the air gap. Unit is available in three sizes according to strength of pull, Series 100, 200, and 300. Each size comes in widths from 6 to 48 inches. **Stearns Magnetic Products,** 635 S. 28th St., Milwaukee 46, Wis.

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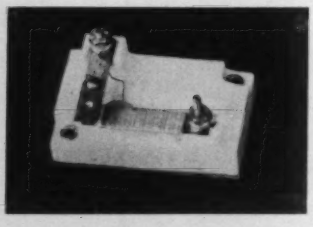
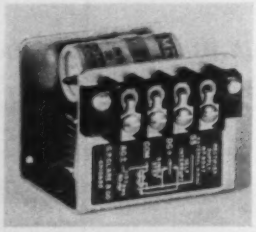


Thermostatic Flasher

Item 454

Line of thermostatic flashers has normally open types for lamp loads and normally closed types for inductive loads. Capacities are up to 600w ac. Flashing rate is 20 times per minute for units rated to 100w, 12 to 16 per minute for larger units. An adjusting screw regulates the proportion of *on* and *off* time. Units operate on 110v ac or dc; special units can be supplied for voltages from 5 to 220v ac or dc. **Betts & Betts Corp.,** 213 W. 14th St., New York 11, N. Y.

Circle 454 on Page 17

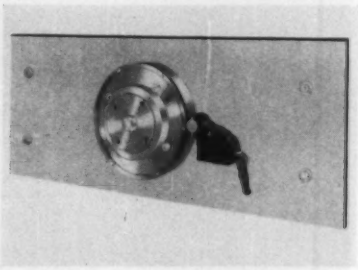


Rectifier

Item 455

Device can operate either a single stepping switch or a group of switches, one at a time. Unit rectifies 115v, 60 cycle ac to operate 115v dc stepping switches. Within its ratings, it can also be used to operate a relay or a group of relays. It can be mounted on either of two surfaces by two No. 6-32 machine screws. **C. P. Clare & Co.,** 3101 Pratt Blvd., Chicago 45, Ill.

Circle 455 on Page 17



Magnetic Storage Drum

Item 456

Unit is suitable for process automation systems and buffer storage applications. Motor, drive, mounting base, bearings, and drum hub are mounted on an aluminum plate. It can be installed in a standard 19-inch rack. Drum diameter, speed, read/record heads, and associated circuitry can be selected to suit individual requirements. **Electronics Div., Monroe Calculating Machine Co.,** Morris Plains, N. J.

Circle 456 on Page 17

Limit Switches

Item 457

Units suitable for industrial applications where restricted space is a prime factor in switch selection. Forged aluminum alloy roller-arm actuators and a high electrical rating are features of line. Model 1LS1 (shown) has an adjustable head assembly that can be mounted in any of four directions. A flush-mounting unit, Model 7LS1, is available. Electrical ratings for the switches are 10 amp, 120, 240, 480v ac; ½hp, 120v ac, 1 hp, 240v ac, 0.8 amp 115v, dc, 0.4 amp, 230v dc, 0.1 amp, 550v dc. Pilot duty rating is 600v ac max. Switches are sealed and the actuators can be field adjusted through 360 degrees and positively locked in any position. **Micro Switch Div., Minneapolis-Honeywell Regulator Co.,** Freeport, Ill.

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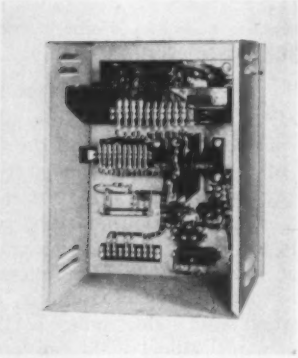


Magnetic Amplifiers

Item 458

Devices capable of close control of heater temperature in electric furnaces and for other applications where kw of power must be controlled by milliwatt signals.

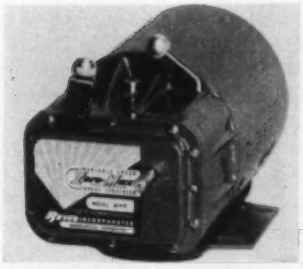
Units are available in sizes ranging from 0.5 to 10 kw, with input resistance of 2000-20,000 ohms, and input ranges of 0.5 ma, 0-15 ma, 4-8 ma and 0.20 ma. They are completely wired ready for installation and connection into existing control systems. **Vickers Electric Div., Vickers Inc.,** 1815 Locust St., St. Louis 3, Mo.

Circle 458 on Page 17

Speed Reducer

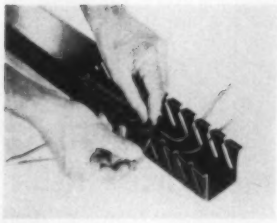
Item 459

Unit features instant reversing, while running or stopped, without reversing the motor. Basic unit includes a speed reducer built onto a G.C. 48-frame motor which drives the reducer through 1:1 helical



gears running in oil inside the housing. Output speed can be set from zero to 400 rpm. Different speeds in each direction can be set by remote control or manually. Different models deliver 10, 15, or 20 inch pounds constant torque. Motor is rated 115v, 60 cycle, single phase, and can be operated in any position. **Revco Inc.**, 1900 Lyndale Ave. S., Minneapolis 5, Minn.

Circle 459 on Page 17

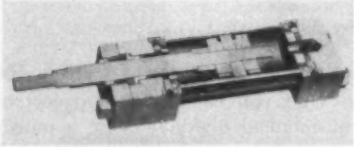


Wiring Raceway

Item 460

Designed to facilitate control panel assembly, wiring raceway is molded of a tough lightweight phenolic. It does not warp under normal control panel temperatures; can be installed without special tools or hardware. There are no metal parts. A feature of the raceway is the Lok-Slot construction that accepts wires readily, and holds them securely while they are being connected. **Stahlin Brothers Inc.**, 232 Maple St., Belding, Mich.

Circle 460 on Page 17



Teflon Sealed Cylinder

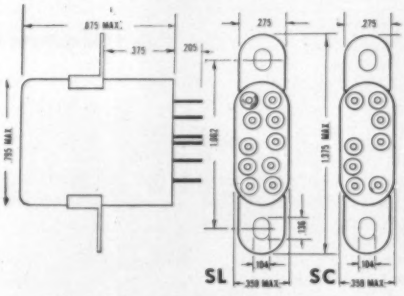
Item 461

Device gives universal resistance to fluids. Features include a

CRYSTAL-CASE SIZE! PERMANENT MAGNET DESIGN.
SHOCK: 100g. VIBRATION: 30g 55 TO 2000cps. NO CONTACT OPENINGS.

SC NON-LATCHING TYPE—This micro-miniature relay sets new standards —in design, in performance, in reliability. Yet the SC conforms to standard dimensions and circuitry and may be used to replace ordinary crystal-case relays. A permanent magnet in the structure provides *at least twice the contact pressure found in relays of comparable size.*

SL LATCHING TYPE—Unique magnetic latch assures exceptional contact pressure. A 1 watt, 3 ms. pulse to either coil transfers contacts. Transfer time is only 0.5 ms. Has the same exceptional shock and vibration characteristics as the SC.



SC and SL Series Engineering Data

Operate Time: 3 MS. max. with 550 ohm coil @ 24 V. DC. (SL: 630 ohm coil at 24 V. DC).
Transfer Time: 0.5 MS max.
Terminals: (1) Plug-in for microminiature receptacle of printed circuit board. (2) Hook end solder for one #20 AWG wire.
Enclosure: Hermetically sealed.
CONTACTS: Arrangement: 2 Form C.
Material: Gold flashed palladium.
Load: 2 amps @ 28 V. DC, resistive; 1 amp @ 115.V. AC, resistive.
Pressure: SC—13 grams min.; SL—16 grams min.
COIL: Power: Approx. 1.0 watt at Nominal Voltage.
Resistance: SL—40 to 1400 ohms; SC—35 to 1250 ohms.
Duty: Continuous.
MOUNTINGS: Bracket, stud and plug-in.

GENERAL: Insulation Resistance: 10,000 megohms, min.
Breakdown Voltage: 1,000 V. RMS.
Shock: 100g.
Vibration: 30g 55 to 2000 cps.; 0.195" max. excursions from 10-55 cps.
Temperature Range: -65°C. to +125° C.
Weight: 17.5 grams (5/8 oz.).

P&B Standard Relays are available at your local electronic, electrical and refrigeration distributors

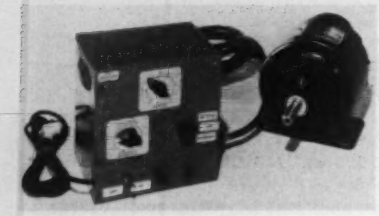
Potter & Brumfield, inc.

PRINCETON, INDIANA · SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

Circle 697 on Page 17

unique tubing end seal and a new piston rod bushing seal which permit use of sealing rings; adjustable screw with a self regulating lock seal is located opposite the ball check and is interchangeable with it. Seals do not have to be changed when different fluids are used or high temperatures met. Plastic is inert to virtually all fluids, including nonflammable fluids, and is resistant to temperatures up to 500F. New design of the seal is a combination of the Teflon seal and a confining shoulder of metal which restricts expansion of tubing, resulting in a metal to metal zero clearance. **Miller Fluid Power Div., Flick-Reedy Corp.**, 2040 N. Hawthorne Ave., Melrose Park, Ill.

Circle 461 on Page 17



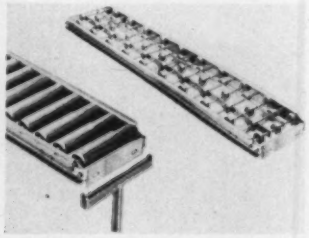
Speed Control

Item 462

Control system is suitable for remote or automatic operation on special applications. Designed for operation of any shunt or compound dc motor to ¼ hp from a standard 117v ac power supply, Model SC-¼ provides variable speed from zero to full motor speed at constant torque, forward or reverse. Motor control can maintain any desired speed uniformly, regardless of line voltage variations as high as 20 per cent. An adjustable dynamic brake is incorporated in the unit to provide any desired degree of braking.

Armature power is supplied from a tube rated at 2.5 amp, with 30 amp instantaneous peak rating. Grid bias is supplied by a transformer through a rectifier-filter network. Bias voltage is controlled by tandem potentiometers mounted on a single shaft, polarized to add positive voltage as bias voltage is reduced, permitting the selection of desired motor speed. Front panel controls include speed selector, brake selector and *forward-off-reverse* switches, power *on-off* switch, and pilot light. **B & B Co.**, 3124 E. 14th St., Oakland, Calif.

Circle 462 on Page 17

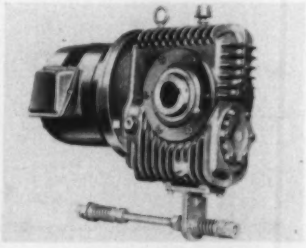


Wheel-Roller Conveyors

Item 463

Portable conveyor features a Quick-Eez coupling. Both ends of the conveyor sections are identical, and each section is a complete unit independent from adjoining ones. Conveyors are equipped with extended end plates which fit down into slotted tops of the tubular stands, and eliminate the need for hooks and rods. This feature eliminates end-for-end shifting and reduces conveyor set-up time. Coupling design is available for both straight and curved mobile conveyor sections. Conveyors are offered in four standard sizes to provide adjustable heights from 12 to 48 inches. Hand lever provides positive lock for supports at selected height. **E. W. Buschman Co.**, Clifton & Spring Grove Aves., Cincinnati 32, Ohio.

Circle 463 on Page 17



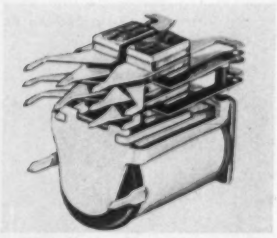
Hollow Shaft Gear Motor

Item 464

A hollow shaft mounting permits driving of shafts in any position with a floating power unit. A simple torque arm ties the gear motor down. Double-enveloping worm gearing with a helical primary allows high output torque ratings. Large taper roller bearings are used to lengthen service life.

A high load carrying capacity is obtained with the hour glass design worm that meshes with a throated gear. The two gears wrap around each other. All teeth in both gears are straight sided and tangent to a common circle, and in contact the full depth of the teeth. One-eighth of the gear teeth is always in mesh and the resulting high area contact between worm and gear teeth spreads unit loads over a greater area. **Cone Drive Gears, Div. of Michigan Tool Co.**, 7171 E. McNichols Rd., Detroit 12, Mich.

Circle 464 on Page 17



Printed Circuit Relay

Item 465

Relay is adaptable to low voltage sensitive applications, and for requirements where one relay must perform a number of switching functions with minimum input power. They can be furnished with great resistance to shock and vibration, and to withstand wide temperature variations. Unit is rated to 230v ac, with full wave rectification for operation from 20 to 400 cps. Contact combinations such as snap action, time delay, and heavy current contacts can be furnished. **Magnecraft Electric Co.**, 3354D W. Grand Ave., Chicago 51, Ill.

Circle 465 on Page 17

Rotary Inductor

Item 466

Unit can be used as an electromechanical dividing head, a multispeed data transmission system, a high precision position servo, an electronic backlash-free gear ratio, a high speed electromechanical phase shifter, or an angular pick off. Device is designed to per-

How to increase production with new tool control methods proved at Ford's Sterling Plant

Scully-Jones "TOOLITROL" System

reduces tool costs and downtime on vital transfer lines

At the Sterling Chassis Parts Plant of Ford Motor Company, Sterling Township, Mich., cutting tools are changed *in groups*, rather than individually, with Scully-Jones "Toolitrol" boards and presetting tools performing the following functions:

1. Preset counters in the panel signal the tool-changers when each cutting tool in the machines reaches its optimum number of cuts.
2. Presetting tools at the board make it easy to adjust one set of sharpened tools in holders to exact depth while another set is producing in the machines.
3. Presetting tools and preset cutting tools with holders are stored in the "Toolitrol" panel, clearly identified by station and spindle.

A fast team method of tool-changing takes maximum advantage of the "Toolitrol" system. A tool-changer and setup man are assigned to each transfer line—a total of six men. Nine other jobsetters form a pool from which teams of men are drawn to quickly change *groups* of tools on any one of three lines. When the "Toolitrol" light signals that any one tool has reached maximum life between sharpenings, counters for other tools are checked, and all tools *closely approaching* the change period are changed at once. Thus, the total *number of downtime periods is greatly reduced*. At the same time, sharpened, preset tools from the "Toolitrol" panel are quickly and easily inserted in the machine—*reducing the length of each downtime period.*

Ask your Scully-Jones representative about a free showing of: "Down with Downtime and Up with Production."

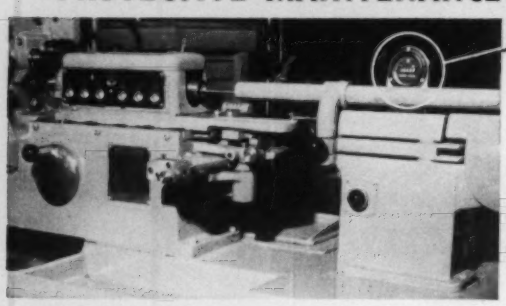
SCULLY JONES

PRECISION HOLDING TOOLS

"Precision Holding" for holding precision

SCULLY-JONES AND COMPANY, 1930 SOUTH ROCKWELL ST., CHICAGO 8, ILL.

AUTOMATION REQUIRES GREATER EMPHASIS ON PROTECTIVE MAINTENANCE



Hobbs HOUR METERS TAKE AWAY THE GUESSWORK!

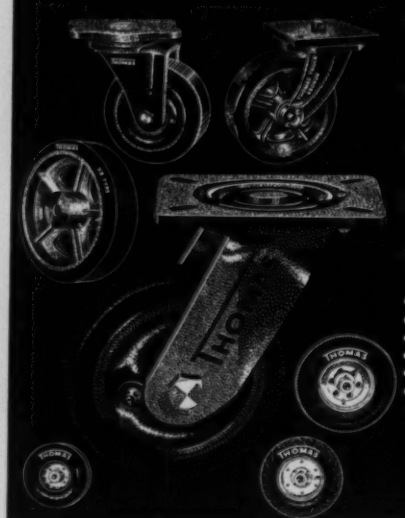
The Hobbs AC Hour Meter indicates operating time of any machine or equipment powered by alternating current — basic time data essential in the study of utilization and production methods . . . and vital for protective maintenance programs. Wide range of applications — small, compact, easy to install. Ruggedly built and sealed against moisture and dust. Powered by an accurate synchronous motor specially designed for this instrument. Easy to read — tells at a glance accumulated time of operation to 10,000 hours, showing 1/10th hours. Also available in 100,000 hour models.

● Ask your supplier . . . or write direct for Catalog AC-587 with complete information.

JOHN W. Hobbs CORPORATION
A DIVISION OF STEWART SW WARNER
2080 YALE BLVD. SPRINGFIELD, ILLINOIS

Circle 699 on Page 17

THOMAS CASTERS & WHEELS



"JOB SUITED" to the Size of your Loads... right for your Floors

WRITE FOR CATALOG NO. CW-56

THOMAS TRUCK & CASTER CO.
720 Mississippi River • Keokuk, Iowa

THOMAS MAKES ALL KINDS OF TRUCKS, SKIDS, CASTERS AND WHEELS

form in a manner similar to that of a conventional resolver that has been geared up 180 to 1. Line includes a 3-inch unit, accurate to 5 seconds of arc, a 7-inch unit with an accuracy to 2 seconds of arc, and a 12-inch unit with accuracy to 1 second of arc. **Farrand Controls Inc.,** 4401 Bronx Blvd., New York 70, N. Y.

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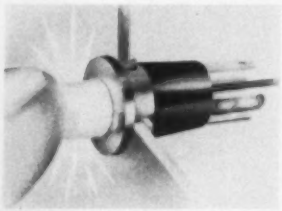

Indicator Switch

Item 467

Designed for pulsing remote controlled relays and indicating their operation, indicator switch is also suitable for a variety of low voltage indicating and switching applications. A pushbutton bulb lens assembly provides fast replacement from the front of the panel. Projecting less than one inch behind the panel, switch has a maximum diameter of 5/8 inch, and up to 225 can be mounted in a square foot.

Location of the bulb in the lens cap places the bulb filaments above the surface of the panel and gives an indication that can be seen at 180 degrees. Electrical layout of the switch allows it to be wired as a momentary contact pushbutton style indicating switch, or as a press-to-test indicating light. The assembly is provided with five external terminals, four of which are tabs. The other is a 12 inch lead of #28 stranded wire. The purpose of one of these tabs is to enable a series of lights to be wired by jumpers from one to an-

other. **Alden Products Co.**, Dept. TS-7, Brockton, Mass.

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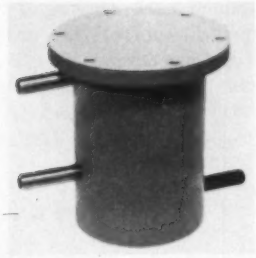

Ultrasonic Transducer

Item 468

Suitable for industrial cleaning and degreasing applications, Model M-203B can operate continuously with 400w of electrical input power. Conversion efficiency of the transducer is 40 per cent. A sound pressure of one million dynes/cm^2 results in the vicinity of the transducer when radiating into open water with 100 electrical watts input to the structure. Unit can be mounted in any position. Operating frequency is 26 kc; impedance is 150+j100 ohms. **Massa Laboratories Inc.**, Hingham, Mass.

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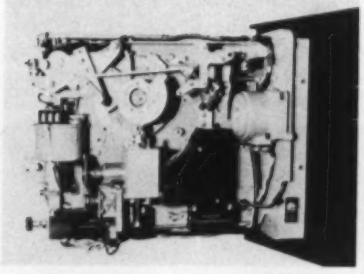


Strip Chart Recorder

Item 469

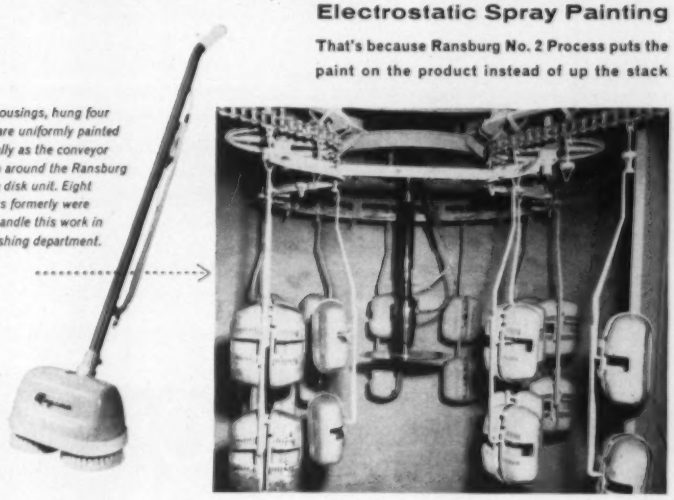
Adaptation of ball and disc integrators to strip chart recorders allows a larger number of readout methods. A synchronous motor for integrating against time is provided, and to integrate against inches the chart drive itself is used. Some of the readout methods that are suitable include use of a visual counter operated from electrical pulses obtained from output contacts, with the manual reset mounted in any number of positions; use of an Identichart,

Regina

Reports 50% Paint Saving with RANSBURG NO. 2 PROCESS

Electrostatic Spray Painting

That's because Ransburg No. 2 Process puts the paint on the product instead of up the stack



Aluminum housings, hung four to a fixture, are uniformly painted electrostatically as the conveyor makes a loop around the Ransburg reciprocating disk unit. Eight hand sprayers formerly were required to handle this work in Regina's finishing department.

The Regina Corporation, Rahway, N. J., replaced hand spray with Ransburg No. 2 Process to paint their twin-brush Floor Polisher and Scrubber, and their Electrikbroom.

Now, a single reciprocating disk unit automatically handles the work which formerly required eight hand sprayers. Even with increased production, Regina is using 50% less paint. Quality of the work is improved with maximum uniformity on all parts.

NO REASON WHY YOU CAN'T DO IT, TOO!

Want to know what Ransburg No. 2 Process will do for you in your finishing department? If your present production justifies conveyorized painting, let us prove the many cost-saving benefits which can be yours. Write for our No. 2 Process brochure which pictures many on-the-line examples of electro-coating on a wide variety of products, and describes our free survey service.

Ransburg ELECTRO-COATING CORP.
Indianapolis 7, Indiana

RANSBURG

Circle 701 on Page 17

printing in digital form on the chart of the same recorder; and conversion of electrical pulses into pips along the edge of the chart with a special marginal pen assembly provided to draw every tenth pip in the opposite direction. **Royson Engineering Co.**, 100 N. Penn St., Hatboro, Pa.

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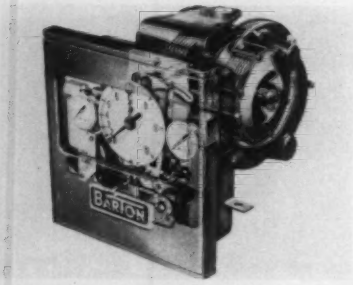

Pressure Controller

Item 470

Device has rupture-proof bellows unit. Model 237 has differential pressure ranges from 0-20 inches W.C. to 0.50 psi with static pressure ratings up to 6000 psi. Control actions include *on-off*, differential gap and proportional; proportional plus reset or proportional plus rate are optional. Unit has a supply pressure of 20 psi and an output of 3-15 psi with 6-30 psi optional. **Barton Instrument Corp.**, 580 Monterey Pass Rd., Monterey Park, Calif.

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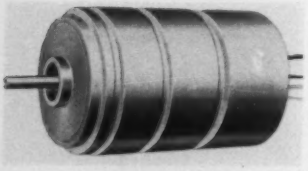

Stepping Motor

Item 471

Bidirectional device translates pulses to incremental shaft positions. It is suitable for rotation of potentiometers, counters, rotary switches, and control mechanisms. A magnetic clutch indexes the shaft. The clutch and detent mechanism are mounted between two solenoids whose armature plates face each other. The clutch rotates with one or the other of the energized armatures to which it has been magnetically attracted, causing shaft rotation. Solenoid de-energizing returns the armature to its original position while the clutch and shaft are held in displaced position by the detent. The clutch surfaces provide a braking action at the end of each step for higher inertia loads. Angular increment per pulse is 36 degrees in either direction at a maximum stepping rate of 15 per second. A load capacity up to 2 lb in. starting torque at 20C is provided. **G. H. Leland Inc.**, 123 Webster St., Dayton 2, Ohio.

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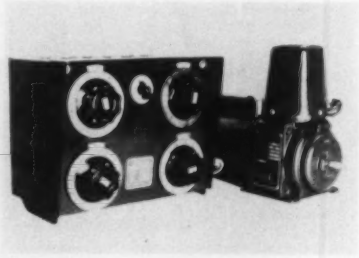


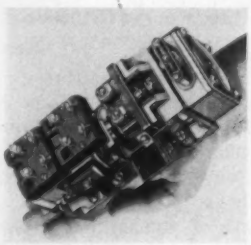
Program Controller

Item 472

Device is capable of machine tool and welding positioner programming, work station control for assembling machines, and dipping machine programming. A vernier dial or revolution counter type control is set on the panel for each position or rate that is to be established. In programmed sequence, each dial or counter assumes command of the setting of a gear motor operator. This shaft-mounted gear motor establishes the position of a tool, the setting of a variable speed drive or valve, or the location of an assembly table or indexing device.

The gear motor is designed to mount in place of handwheels or control cranks providing automatic sequencing through the use of this combination. The controller includes built-in anticipation and accuracy adjustments that signal the gear motor to slow down as the desired setting is approached, eliminating overtravel and hunting. The controller is designed to handle operators from sub-fractional to 10 hp. Gear motor can be furnished in explosion proof or standard enclosure. Commands can start from controls set at the panel of the controller, from remotely located potentiometers, or from punch card reading devices. Sequencing control is provided with reset accuracies of 1/5 of 1 per cent of full scale as standard and with higher accuracies available in special models. **Jordan Co. Inc.**, 3235 W. Hampton Ave., Milwaukee 9, Wis.

Circle 472 on Page 17



Timing Relay

Item 473

Small, compact pneumatic timing relay is suitable for use in restricted space requirements of machine tool control panels. Relay measures 2½ inches wide by 7⅝ inches high. It has an adjustable timing range of 0.2 second to three minutes with an accuracy of ±10 per cent. The device can be converted from *on* delay to *off* delay operation without the need of special tools. Class 9050, Type B, can be used on circuits up to 600v ac. **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis.

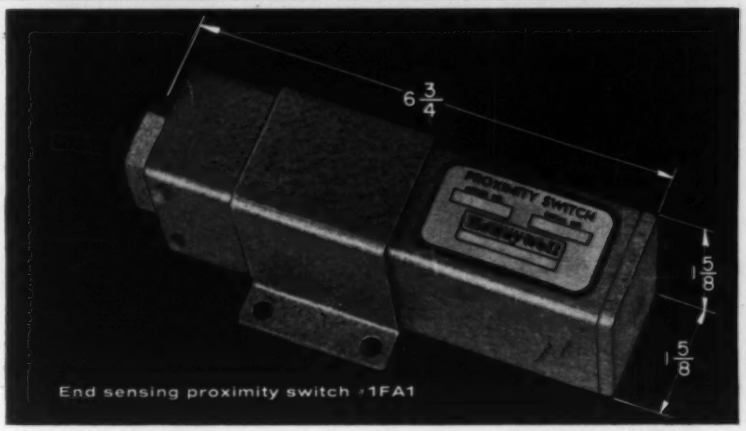
Circle 473 on Page 17

Pushbutton Station

Item 474

Line of pushbutton control stations features a base mounted control mechanism and front accessible wiring terminals. Reversible

MICRO SWITCH . . . FIRST IN PRECISION SWITCHING



End sensing proximity switch · 1FA1

NEW!

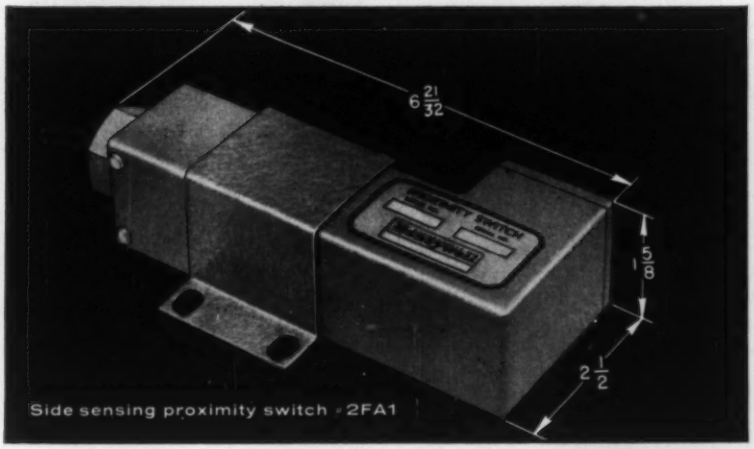
The Honeywell Proximity Switch

Ideal limit switch on automatic machine tools—for use in materials handling control—for programming operation of transfer machines in automation equipment.

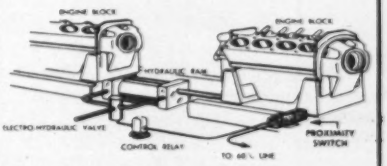
Consider these important features of this sensational magnetic switching device—

- **LONG LIFE**—No moving parts . . . no electrical contacts . . . no vacuum tubes.
- **HIGH SPEED OPERATION**—Will operate as many as 600 times a minute.
- **EXTREMELY SENSITIVE**—Can be operated by ferromagnetic surface as small as ¼ in. square and 1 in. long.
- **RESISTS ENVIRONMENT**—Relatively insensitive to ferrous chips . . . potted to permit operation in high humidity, corrosive atmosphere, or in presence of cutting oils . . . protected by heavy steel housing.

(*Request Data Sheet Nos. 119 and 130*)



Side sensing proximity switch · 2FA1



Proximity switch used to activate an engine block transfer line

SPECIFICATIONS

EXCITATION
100-125 v, 60 cps, 2 watts (nominal).

OUTPUT
(a) switch "on"—12 vdc minimum into 250 ohm load; (b) switch "off"—4 vdc maximum into 250 ohm load.

SENSITIVITY
When a block of ferromagnetic material is moved parallel to and within ½ in. of its pole face, the Proximity Switch will operate the control relay.

REPEATABILITY
When a block of ferromagnetic material is moved parallel to and within ½ in. of its pole face, the Proximity Switch will repeat its pick-up and drop-out point within 3/32 in.

DIFFERENTIAL
When a block of ferromagnetic material is moved parallel to and within ½ in. of its pole face, the Proximity Switch will have a differential distance between pickup and drop-out of less than 7/32 in.

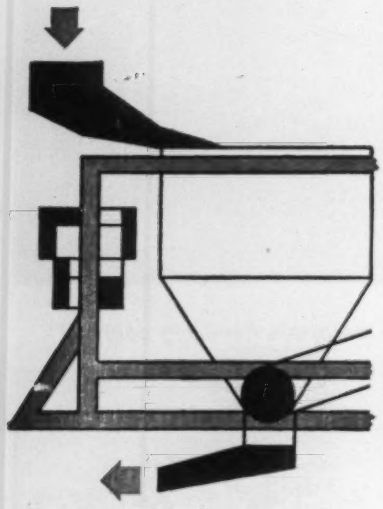
Any MICRO SWITCH field engineer will be glad to work with you regarding the wide applications for this new Proximity Switch.

MICRO SWITCH
A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY
In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Circle 702 on Page 17

UNITIZED WEIGHING

provides automatic batching



For sequence or continuous automatic batch feeding, W-C offers pre-engineered, "building-block" systems to meet virtually all requirements.

- **Batch-in or batch-out**
- **Solids and liquids**
- **Single or multiple materials**
- **Ratio batch and proportioning**

In a full range of sizes, you have your choice of weigh hoppers, feeders, weight transmitters, scales . . . semi-automatic or fully automatic controls, either "on-the-spot" or remotely located. You also have your choice of electric or pneumatic operation plus the overall flexibility and economy that only W-C UNITIZED WEIGHING Systems offer in fulfilling present *and future* weight batching requirements.

Write for descriptive literature.

W-C

WEIGHING & CONTROL COMPONENTS, Inc.

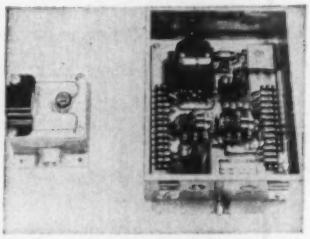
206-C LINCOLN AVENUE, HATBORO, PA.

Circle 703 on Page 17

formed steel base includes knockouts and pipe connections which provide wiring from either end or straight through. Controls can be furnished with one normally open contact, one normally closed contact, or one normally open and one normally closed contact on each button.

The control mechanism can be removed from the base by loosening two screws. The ac contact ratings are 3 amp, 110v; 1.5 amp, 220v; 0.75 amp, 440-480v; and 0.6 amp, 550-600v. The dc contact ratings are 1.1 amp, 115v; 0.55 amp, 230v; and 0.2 amp, 550-600v. **Furnas Electric Co.**, 1128 McKee St., Batavia, Ill.

Circle 474 on Page 17



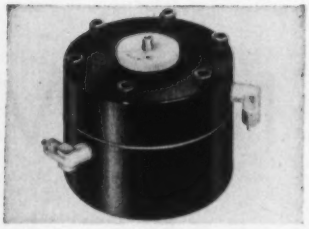
Vibration Monitor System

Item 475

Device is suitable for protection of pumps, motors, blowers, compressors, centrifuges, engines, and turbines. System ignores starting vibration and transient shocks normal to operation, but is sensitive to increases in vibration. The system includes a Model 65 detector, for mounting on the protected equipment, and Model 651 A. C. control unit which is wired to the detector through a ¾ inch conduit.

In operation, the detector trips whenever the vibration exceeds the preset vibration level. The control unit must reset the detector in rapid sequence several times before the shutdown time delay relay, selected for a 2 or 5 second delay, will actuate. The unit is held inoperative for a selected time of up to 120 seconds after starting to allow the protected equipment to reach full speed. No vacuum tubes are used in the system, and the rectifier and thermal time delay heater elements are *off* when the system is operating. **Instrument Div., Robertshaw-Fulton Controls Co.**, 2920 N. Fourth St., Philadelphia 33, Pa.

Circle 475 on Page 17

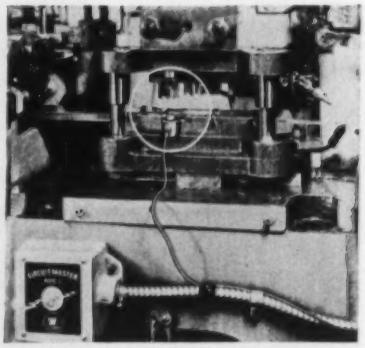


Pressure Comparator

Item 476

Instrument is adaptable to data reduction systems and can be used with any noncorrosive fluid. Comparator relates an unknown pneumatic signal to a reference pressure. When the two pressures reach an equilibrium, an electrical contact is opened. Leads from the unit can be used to indicate a zero differential pressure. Life of the device is 500,000 cycles. **Fischer & Porter Co.**, 92 Jacksonville Rd., Hatboro, Pa.

Circle 476 on Page 17



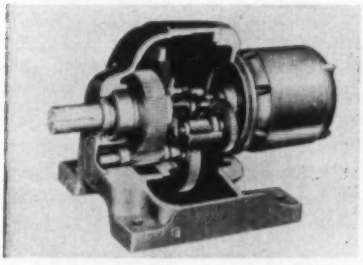
Die Press Control

Item 477

Electronic mechanical press control prevents tool and die damage caused by mechanical overload. Device is designed for power presses using dies incorporating flattening, forming, coining, and similar operations where the closed position of the die is fixed by any of the above operations. A compensator unit automatically adjusts itself to normal temperature changes, voltage fluctuations, and all mechanical changes which occur during the running of an automatic ma-

chine. Model RI includes a sensing unit and electronic control. On first contact with an overload caused by jams, improper feeding, pileups, oversized stock, tool dullness, or freezing of parts, the sensing unit sends an impulse to the electronic control unit which relays this impulse to the clutch solenoid, stopping the press immediately. **Wintriss Inc.**, 20 Vandam St., New York 13, N. Y.

Circle 477 on Page 17



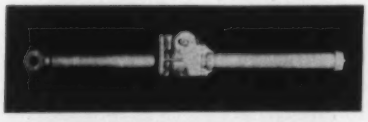
Parallel Shaft Gear Motor

Item 478

Line of gear motors includes integrally-mounted and motor-coupled types. Permanent alignment in the gear heads and motors is built in, giving longer life for helical gears. Protection against oil leakage is provided through double seals on honed surfaces on the high speed shafts and service proved seals on output shafts. Changing motors is possible without draining the oil.

A feature of the unit is the insulation which incorporates glass mica and silicone. All motor housings and the smaller gear cases are of heat treated aluminum alloy. **Electra Motors Inc.**, Dept. PI, 1110 N. Lemon St., Anaheim, Calif.

Circle 478 on Page 17



Worm Gear Screw Jack

Item 479

Device is suitable for precision jacking, pushing, and pulling operations, and for linear actuation. Jack can be used in any position, and is applicable for adjustment

"A case for automation"

Boxes seal themselves on this streamlined Hotpoint packaging line. Close tolerance H&D corrugated boxes make it work. Result: Faster packing, 30% labor savings. Better see H&D.

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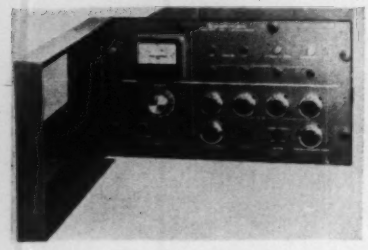
Circle 704 on Page 17

of rolls, or other machine members, loading platform and feed table adjustments, raising and lowering of all kinds of production equipment, and stabilizing and leveling mobile units. Device is actuated by an aluminum bronze nut, which is cast integrally with the worm gear and mounted between two antifriction thrust bearings to withstand bidirectional vertical loads. Gear is driven by an alloy steel worm mounted on tapered roller bearings. Jack shown has a 15-ton capacity and worm gear ratio is 8 to 1, with 32 revolutions of the worm giving one inch of travel. Power source can be either manual or motor with reducer unit. Four-way miter box assemblies are available for multiple systems requiring synchronization. **Jack Div., Joyce-Cridland Co.**, 2027 E. First St., Dayton 3, Ohio.

Circle 479 on Page 17



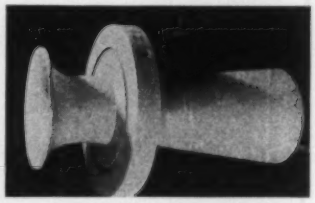
Control/Analyzer Unit

Item 480

Device is capable of giving a continuous analysis of as many as four components of a specific gas stream. Model 120A consists of two instruments which can be placed 1500 feet apart and maintain accurate measuring and recording. The gas control unit has a visual and permanent recorder readout, an accuracy of ±1 per cent, and an integrated test circuit to facilitate periodic maintenance without disassembly.

Analyzer has a temperature control of ±2C for operation up to 110C and provision for true split column operation allowing complete analysis of up to four high or low boiling point components in a single stream. Heart of the gas handling system is a single action five-way linear sample injection valve which duplicates the action of five conventional two - way valves. **Process Instruments Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif.

Circle 480 on Page 17



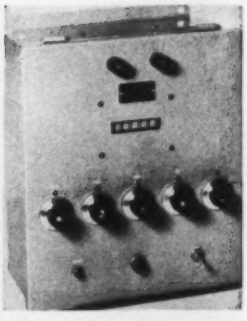
Plastic Flow Nozzle

Item 481

Unit is capable of metering many of the corrosive fluids such as non-oxidizing acids, corrosive salts, and weak alkalis, which are unsuitable to metal constructions. The nozzle, made of fiberglass-reinforced polyester plastic can also be used for some alcohols, formaldehyde, refinery crudes, and gasoline, with modified designs to handle slurries.

Model NZRP is available in sizes ranging from 2 to 24 inches, is suitable for pressure up to 150 psig and temperatures up to 250F on most applications. Feature of the unit is an uncalibrated accuracy within ±1 per cent of the actual rate of flow. **Builders-Providence Inc.**, 345 Harris Ave., Providence 1, R. I.

Circle 481 on Page 17



Predetermining Counter

Item 482

Electric predetermining counter has an automatic reset. Five set control knobs can establish any of the 100,000 possible control points. Electromagnetic counting unit permits the use of a wide variety of remote actuators, switches, contactors, electric eyes, or other sensing units. This unit plus several electrical control circuits allows complete remote operation of the controlled equipment. Predetermining control units can be grouped in a single central location for setting the quantities and visual monitoring of the accumulated counts. Unit operates on 115v, 50-60 cycles ±10 per cent variation. **Electronic Control Div., Veeder-Root Inc.**, Hartford 2, Conn.

Circle 482 on Page 17

Automatic Grease Cup

Item 483

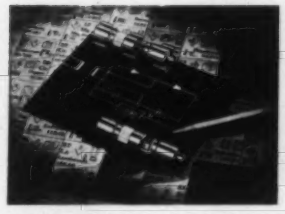
Automatic grease cup eliminates greasing of electric motors, pumps, blowers, shafts, fans, and other machinery by irregular methods. Unit includes a neoprene disc which can be inflated into a ball, holding up to 2 ounces of grease. The disc is filled with a standard grease gun through a fitting on the side. A clear plastic cylinder protects the neoprene ball and allows the maintenance man to see the ball as it fills with grease. As the bearing uses grease, the ball deflates, indicating the quantity of grease remaining. Because of the compression of the neoprene ball and the vacuum created by the motion of the shaft, grease is fed automatically into the bearing only as it is needed. **Visiball Mfg. Co.**, P. O. Box 7021, Fort Worth, Texas.

Circle 483 on Page 17

Cartridge Rectifier

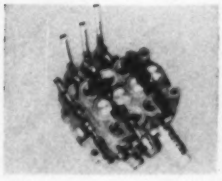
Item 484

Cartridges are applicable to industrial equipment operating in high ambient temperatures from −55C to 150C. Some of the appli-



cations include mounting in dc relay housings to eliminate the need for separate power supplies; replacing ac relay units in commercial and professional buildings, where hum is objectionable; providing dc power for solenoids, counters, variable speed controls; and for the supply of power to the fields of small dc motors. Each rectifier is a voltage doubler with a maximum rating per leg of 3200 piv. Two units can be connected as a single phase, full wave bridge, capable of delivering 1900v dc at 90 ma for an input voltage of 2240v rms at 75C. **International Rectifier Corp.**, El Segundo, Calif.

Circle 484 on Page 17



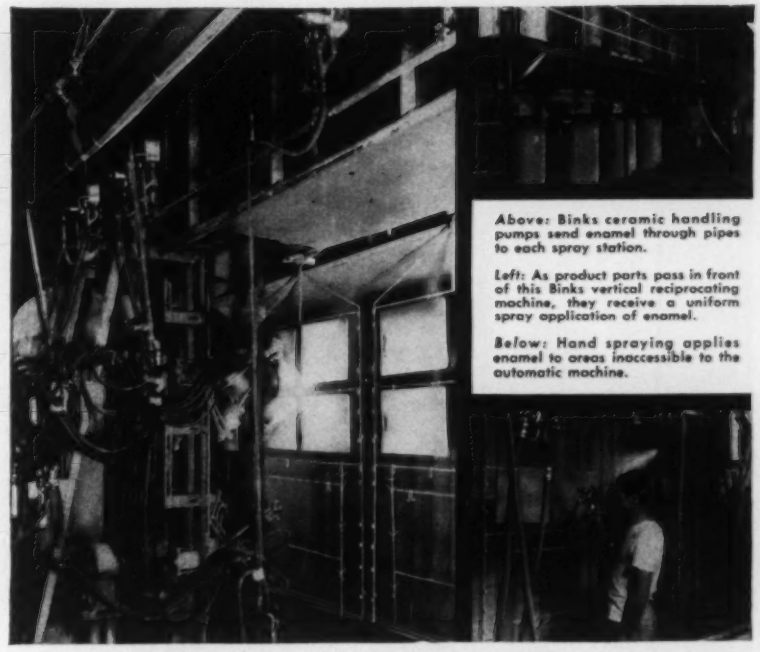
Hydraulic Control Valve

Item 485

Unit provides four positions of control; raise, lower, float, and neutral; with or without detent. The float position on a grader permits the blade to freely follow the general contour of the land, within the set limits of operation. The detent feature permits locking the plunger in any desired position. Individual checks are built into each circuit.

The positive pilot operated relief valve in Model 3200 allows setting the valve to within a maximum of 50-lb variation. It can be adapted to a wide range of equipment applications. Unit is available with one through six plungers, in completely balanced design with plungers sealed at each end. **Hydraulic Unit Specialties Co.**, P. O. Box 257-D, Waukesha, Wis.

Circle 485 on Page 17



Above: Binks ceramic handling pumps send enamel through pipes to each spray station.

Left: As product parts pass in front of this Binks vertical reciprocating machine, they receive a uniform spray application of enamel.

Below: Hand spraying applies enamel to areas inaccessible to the automatic machine.

"Only Binks could give us a circulating system for enamel"

...Whirlpool Corporation, St. Joseph, Mich.

"Since we were starting from scratch, there was no reason why all the latest in finishing equipment and technique should not be incorporated in our new plant," reports ceramic engineer, Charles Cook.

Binks PM 120 regulators make a circulating system possible. The Whirlpool Corporation wanted centralized preparation and mixing control of enamel to avoid all the problems inherent to having individual pressure tanks at each spray station. Binks finishing engineers recommended a circulating system which would carry the enamel from a central location through pipes to each spray station in the plant. Only Binks PM 120 pressure regulators make such a system possible. Installations in other plants, such as Hotpoint, have proven that only these regulators have the ability to stand up under the abrasive wear and tear of frit.

Job-tested spraying equipment. Both automatic and manual Binks spraying equipment were installed to provide uniform finishing under a variety of application conditions. All the spray guns are especially equipped to take the wear of frit.

Learn how Binks extensive finishing experience and equipment can be of benefit to you. Binks finishing engineers will be glad to show you how the proper spraying equipment can help you produce better finishes at lower cost. There is no obligation. Just contact your nearest Binks Branch Office or, if you prefer, write direct to the address below.

Ask about our spray painting school
Open to all...NO TUITION...covers all phases

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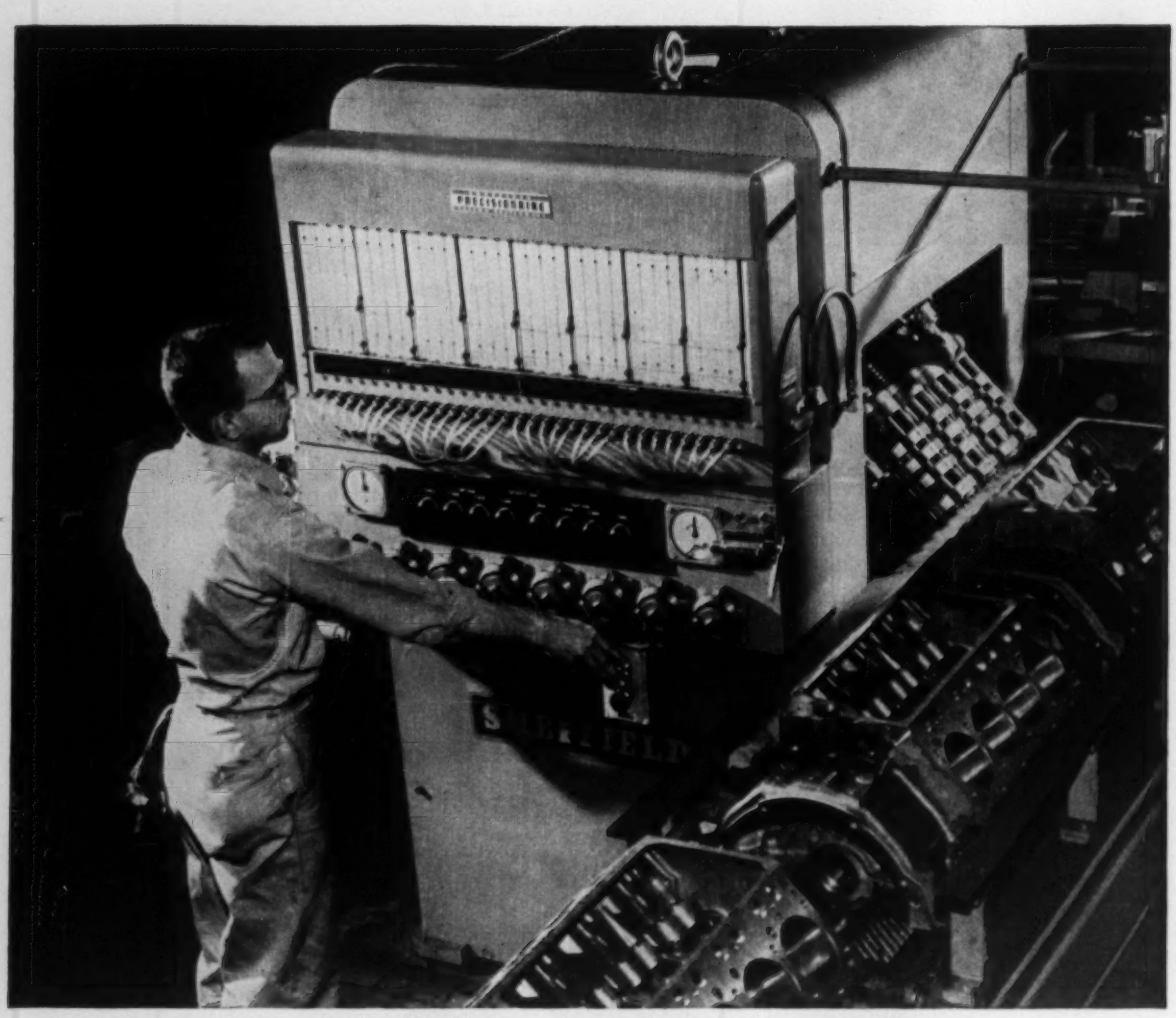
Circle 705 on Page 17



COMBAT RISING PRODUCTION COSTS WITH HIGH SPEED INSPECTION

Gaging is an essential manufacturing operation just as machining is. Both contribute to manufacturing costs. When, through improved methods, either can be done faster, more effectively and with less effort, production costs drop.

A case in point is this Sheffield Precisionaire which checks 32 dimensions simultaneously at the rate of approximately 60-75 cylinder blocks per hour. The size classification of each bore is stamped on the block. Thus, with selective assembly, broad manufacturing tolerances do not jeopardize precision fits.

This is one of the many cost-saving achievements of Sheffield's Autometrologists. Others involve any possible combination of Automatic Gaging with:

- Machine Control
- Sensing and Prediction
- Feedback
- Sorting by Classification Category
- Completely Automatic Assembly

If you contemplate reducing your costs through automation, utilize the ingenuity and resourcefulness of Sheffield's large staff of Autometrologists. Write to the Sheffield Corporation, Dayton 1, Ohio, U.S.A., Dept. 3.

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catalogs and literature

Latest automation information. For copies use card page 17.

Glue Machine Maintenance

International Paper Box Machine Co., 315 Main St., Nashua, N. H.—60 *page handbook*—"International Tips" contains ideas and suggestions for getting the best performance from gluing machines. Proper ball bearing maintenance, method of cleaning gluepots, how to remove excessive vibration, and choosing the proper adhesive for use in high-speed folding box gluing machines are a few of the subjects discussed. Numerous drawings and photos help illustrate the advantages of using these methods.

Circle 486 on Page 17

Process Control Instruments

Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio—Four bulletins describe line of process control instruments for indicating, recording and controlling temperature, pressure, and level flow. Series A-801 covers details on the controller, manual control unit, and recorders and indicators. Tables of specifications are also included.

Circle 487 on Page 17

Marking Equipment

Industrial Marking Equipment Co. Inc., 454 Baltic St., Brooklyn 17, N. Y.—8 *page bulletin*—Line of marking, dating, and coding machines is illustrated. Technical data on a conveyor line marker, automatic printer, and coding attachment are given.

Circle 488 on Page 17

Rotary Switch

E. W. Bliss Co., 1375 Raff Rd. S.W., Canton 10, Ohio—4-*page pamphlet*—Mechanical limit switch which controls the starting, stopping, interlocking, time-motion, sequencing, and recycling of machine tools is described in Bulletin 33-A. Features of the switch are noted and a schematic drawing of the operation of a two-cam circuit is included.

Circle 489 on Page 17

Digital Pulse Decoder

Electrical Communications Inc., 765 Clementina St., San Francisco 3, Calif.—12 *page booklet*—Various applications of the decoder, an electromechanical switch which responds to pulses formed by a telephone dial or other sources, are described. Operation, code settings, and installation are explained.

Circle 490 on Page 17

Electronic Control

Robotron Corp., 21300 W. Eight Mile Rd., Detroit 19, Mich.—12 *page bulletin*—Line of industrial electronic controls for automated processes such as resistance welding, automatic machine tools, precision test equipment, and safety equipment is described. Data on company's engineering and research departments are also included.

Circle 491 on Page 17

Direct Flame Heating

Selas Corp. of America, Dresher, Pa.—10 *page bulletin*—Open heating for flame-hardening, flame-annealing, brazing, preheating and de-scaling is discussed in Bulletin S-1054. Construction of a superheat burner is described and the combustion sytem of which the burner is a part is explained. Illustrative examples of various applications are included.

Circle 492 on Page 17

Adjustable-Speed Drive

Direct Current Motor & Generator Dept., General Electric Co., Erie, Pa.—16 *page booklet*—Features and advantages of a Speed Variator are given in Bulletin GEA-6643. Various components in the packaged drive are described and illustrated in color. A slide rule for determining variable base dimensions of differently rated equipment is also included.

Circle 493 on Page 17

Groove Grinding

Jones & Lamson Machine Co., Springfield, Vt.—6 *page pamphlet*—Question and answer discussion on perpetual form control for grinding wheel dressing is given. Examples of narrow dimensional limit groove grinding on an automated basis are noted. The method described was jointly developed by Jones & Lamson and Koebel Diamond Tool, Detroit, Mich.

Circle 494 on Page 17

Punched Card Reader

Electronics Div., Peerless Electric Co., 1401 W. Market St., Warren, Ohio—5 *page bulletin*—Line of static punched card readers suitable for use with industrial processing and control systems is described in Bulletin XR-7. Operating characteristics, connector components, and available top and bottom plate configurations are noted. Schematic diagrams explain the card reader's operation.

Circle 495 on Page 17

Production Control

Industrial Nucleonics Corp., 1205 Chesapeake Ave., Columbus 12, Ohio — 8 *page bulletin* — Mounting arrangement for measurement and

control equipment is discussed in Bulletin E-157. Construction, wiring, test boards, components, and remote installation are explained.

Circle 496 on Page 17

Sheet Handling Equipment

Dexter Folder Co., 219 E. 44th St., New York, N. Y.—4-page pamphlet—Heavy-duty handling equipment for automatically feeding and delivery piling ferrous and non-ferrous metal sheets is described. Operating speeds, load capacities, and specifications are noted. Smaller size equipment is listed.

Circle 497 on Page 17

Die Feeds

H. E. Dickerman Mfg. Co., 321 Albany St., Springfield, Mass.—8 page bulletin—Cam actuated die feeds for punch press operation are described. Features and specifications of 3 inch and 6 inch units are noted, and operating principles explained. Illustrations of typical feed applications are included.

Circle 498 on Page 17

Flexible Shafts

S. S. White Industrial Div., 10 E. 40th St., New York 16, N. Y.—12 page bulletin—Data on line of flexible shafts for remote control, power drive, and coupling applications are given in Bulletin 5601. Functions, advantages, and characteristics are explained. Descriptions of various types of shaft casings are noted and dimensions for various shafts are also included.

Circle 499 on Page 17

Processing Equipment

Sprout, Waldron & Co. Inc., Muncy, Pa. — 20 *page bulletin* — Processing equipment and systems for use in chemical, processing, and paper and pulp industries are described in Bulletin 178. Applications and advantages of equipment such as vertical mixers and pelleting machines are covered. Lists of materials handled by the various types of equipment are included.

Circle 500 on Page 17

Embossing Presses

Minster Machine Co., Minster, Ohio —8 page bulletin—Knuckle joint embossing presses for sizing and coining applications are described in section 11, of Series 90. Design and construction features are noted, specifications given, and photographs of typical operations included. A schematic drawing of the recirculating lubrication system is also included.

Circle 501 on Page 17

V-Belt Drives

Dodge Mfg. Co., Mishawaka, Ind.—108 *page catalog*—Data on V-belt drives for power transmision machinery are given in Bulletin A661. Various sections cover standard, variable speed, and special drives; taper-lock sheaves; sealed life V-belts; and taper-lock bushings, and hubs. Installation photos are given, and tables noting horsepower capacities, belt speeds, center distances, and sheave diameters are included.

Circle 502 on Page 17

Web Control Systems

Isotope Products, 1711 Elmwood Ave., Buffalo 7, N. Y.—8 page bulletin—Basis weight and moisture control systems for the paper industry are discussed in Bulletin 19. Advantages and applications of systems for coating and impregnation process control are also noted.

Circle 503 on Page 17

Self-Locking Connectors

Avnet Interlock Corp., 8966 National Blvd., Los Angeles 34, Calif.—24 *page catalog*—Line of connectors is described. Specifications, dimensions, and wiring instructions are noted, and a drawing showing locking and contact action of the slide and hook type connector is included. Electrical and mechanical characteristics are also covered.

Circle 504 on Page 17

Interfloor Conveying Systems

Gifford-Wood Co., Hudson, N. Y.—4 *page pamphlet*—Automatic interfloor conveying system is explained. Advantages of the system are noted and schematic drawings show various plans. Illustrations of equipment in operation are included.

Circle 505 on Page 17

Punch Card Control

Sundstrand Machine Tool Co., 2531 Eleventh St., Rockford, Ill. — 6 *page pamphlet*—Advantages of punch card control on a multi-cycle single point production lathe are explained. Operational sequence is given and schematic drawings included.

Circle 506 on Page 17

Instrument Accessories

Foxboro Co., Foxboro, Mass.—60 *page catalog* — Specifications, part numbers, and prices for more than 250 instrument parts and supplies are given in Catalog 500. Components such as pressure gages and flow meter accessories, thermometer wells, bushings and flanges, and thermocouples are noted and illustrated.

Circle 507 on Page 17

Engineered Fasteners

Shakeproof, div. of Illinois Tool Works, St. Charles Rd., Elgin, Ill.—20 *page booklet*—Cost reduction possibilities through preassembly and quality improvement in the field of fastenings is the subject of booklet. Charts and figures show advantages of production buying of engineered fasteners.

Circle 508 on Page 17

Weight Measurement & Control

Weighing and Control Components Inc., 321 Lincoln Ave., Hatboro, Pa.—20 *page booklet*—The assembly of an automatic weighing system by "building block" techniques, using unitized weighing components is discussed in Catalog 12. Batching and continuous weighing methods are explained. Pneumatic and electrical weight transmitters are also covered. Company's line of conveyor scales and weigher-feeders are illustrated.

Circle 509 on Page 17

Automatic Stamping Presses

Brandes Press Co., 6408 Euclid Ave., Cleveland 3, Ohio—14 *page booklet*—The advantage of automatic stamping presses in industry for high production operations is discussed. Features of the inverted type press, with crankshaft located below the bed, are covered; specifications and illustrations are also included.

Circle 510 on Page 17

Casting Machine

Lobeck Casting Processes Inc., 114 E. 32nd St., New York 16, N. Y.—4 page pamphlet—Data on continuous casting machines for the production of

heavy and light nonferrous metals is given in Bulletin 571. Billet and slab casting techniques are described, and details of machine construction and operation are noted. Illustrative examples of casting operations are also included.

Circle 511 on Page 17

Air Control Valves

Hanna Engineering Works, 1765 *Elston Ave., Chicago* 22, *Ill.*—8 *page bulletin*—Five basic models suitable for remote control of master valves, directional control of small single acting cylinders, and for shut-off control are described in Catalog 262. Flow and piping arrangements are covered, and suggested control circuits given.

Circle 512 on Page 17

Relays & Switches

Automatic Electric Sales Corp., Northlake, Ill.—Collection of reprints discusses techniques of relay and switch design and manufacturing. Illustrative examples of typical applications are given, and features of various relays noted.

Circle 513 on Page 17

Closed Circuit Television

Industrial Electronics Div., Technical Products Dept., General Electric Co., Electronics Park, Syracuse, N. Y. —12 *page booklet*—Principles of operation in a closed circuit television system are explained in Bulletin ECL-53. Various pieces of equipment are illustrated, their features noted and mechanical specifications given. Typical equipment arrangements are also suggested.

Circle 514 on Page 17

Label Imprinter

Oliver Machinery Co., Grand Rapids, Mich.—4 *page pamphlet*—Machine which labels all types of prepackaged goods such as food items and industrial parts is described. Features such as rapid changeover from one type of label to another, are noted. Specifications and illustrations of the machine are given.

Circle 515 on Page 17

Switches for Machine Tools

Micro Switch, Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.—8 *page bulletin*—Heavy duty precision switches for machine tools and other industrial equipment are described. Data on the snap-action basic switch is given. Actuator designs for various models are also included.

Circle 516 on Page 17

Viscosimeters

Norcross Corp., 247 *Newtonville Ave., Newton* 58, *Mass.*—10 *page bulletin* — Automatic viscosity control systems are explained. Principle of operation and typical applications are described, and advantages given. Illustrations of various models are included.

Circle 517 on Page 17

Shaft Angle Converters

Instrument Development Laboratories Inc., 67 *Mechanic St., Attleboro, Mass.*—4 *page pamphlet*—Units which convert rotary motion into a coded system of numbers is described. Design features are noted and performance data given. Characteristics of available models are also listed.

Circle 518 on Page 17

Data Processing System

Systems Div., Beckman Instruments Inc., 325 *N. Muller Ave., Anaheim, Calif.*—8 *page bulletin*—Data system for process industries is the subject of brochure. The applications of systems to present day process plant control and provisions for future expansion are described. The economics and reliability of automatic data processing are explained.

Circle 519 on Page 17

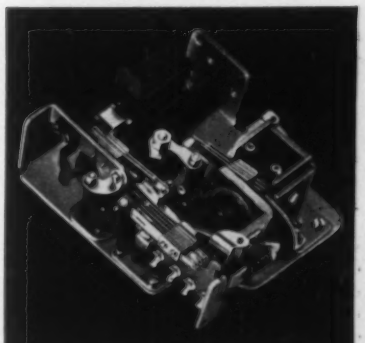
Hairsprings

F. N. Manross & Sons Div., Associated Spring Corp., Bristol, Conn. —8 *page bulletin*—Data on hairsprings for instruments, gear trains, clocks, and other fine mechanisms are given. Recommended materials for specific applications are noted, and formulas for calculation of torque, stress, and stress concentrations are included.

Circle 520 on Page 17

Single Spindle Automatics

Cleveland Automatic Machine Co., 4932 *Beech St., Cincinnati* 12, *Ohio*— 4 *page bulletin* — Machines suitable for producing such parts as shafts, arbors, spindles, studs, pins, and axles are described. Construction features



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The lightweight Deca Switch offers exceptional reliability and compact ruggedness, plus these added features:

- positive stepping action with special locking device to eliminate bounce of wipers and off-normal contacts when the switch returns to the home position;
- 4 banks of 11 contacts each;
- such time-proven XY advantages as dust-free vertical wire banks, bifurcated wipers, dependable release magnet mechanism, and long-wearing, case-hardened working parts with Parco-Lubrite rust-resistant, oil-retaining finish;
- fast operate and release time.

You can order XY Deca Switches in a wide variety of off normal and release magnet spring combinations to suit your specific requirements. Compact and light, the switches are 4¾" long, 4" wide, 1½" high and weigh 20¼ ounces.

Complete technical details are contained in Bulletin T-5001, available on request.

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Circle 707 on Page 17

are explained and illustrated. Specifications and a speed chart for spindle drive are also included.

Circle 521 on Page 17

Air Operated Valves

Conoflow Corp., 2100 *Arch St., Philadelphia* 3, *Pa.*— 8 *page bulletin* —Line of air operated Saunders valves is described in Bulletin HB-6. Construction details and operating characteristics are given. A section on sizing data for proper selection of valves is also included.

Circle 522 on Page 17

Liquid Buffing Compound

Hanson-Van Winkle-Munning Co., Grand Rapids, Mich.—4 *page pamphlet*—Elements of a buffing system which include a pump, master control, and spray guns, and methods of installation are explained in Bulletin LC-100. Advantages of the system and finishes suitable for it are given.

Circle 523 on Page 17

Portable Belt Conveyor

E. W. Buschman Co., Clifton & Spring Grove Aves., Cincinnati 32, *Ohio* — 4 *page bulletin* — Aluminum units suitable for heavy duty loading, unloading, stacking, and boosting at angles up to 30 degrees are described in Bulletin 50 AA. Drawings and charts of proper operational adjustments are given; component specifications and optional equipment noted. Available sizes are also listed.

Circle 524 on Page 17

Production Control

Automation Div., Patterson-Emerson-Comstock Inc., 313 *E. Carson St., Pittsburgh* 19, *Pa.*—16 *page booklet*—Production control through automation is the subject covered in booklet. Basic principles of automation are discussed, a definition of the automation engineer given, and some of the procedures that have been found useful in the development of automation are also noted.

Circle 525 on Page 17

Timing Motors

A. W. Haydon Co., Dept. RWP, Waterbury, Conn.—25 *page handbook* —Collection of engineering bulletins on units such as repeat cycle timers, time delay relays, elapsed time indicators, and stop clocks is given. Numerous illustrations of timers, dimensional drawings, charts and diagrams, and part numbers for relays, indicators, and clocks are included.

Circle 526 on Page 17

Air/Hydraulic Cylinders

Petch Mfg. Co., 463 *York Rd., Detroit, Mich.*—12 *page bulletin*—Five types of cylinders are covered. Data on air and low pressure hydraulic, high pressure hydraulic, Pemaco air and hydraulic, automation standard air and hydraulic cylinders of bores from 1 to 10 inches, and special cylinders to 16 inch bore are given. Dimensions and illustrations of various models are noted.

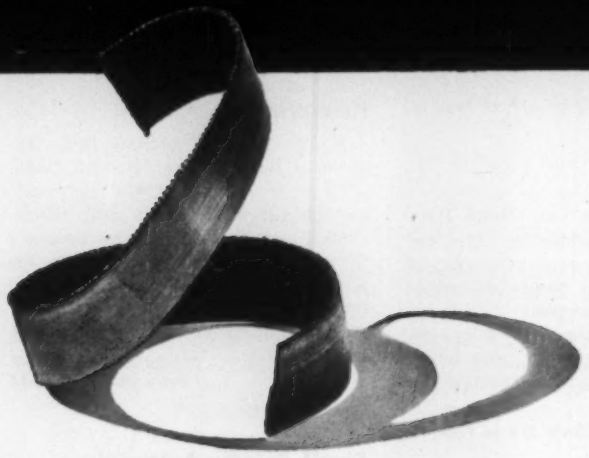
Circle 527 on Page 17

Speed Reducers

Cone-Drive Gears, Div. of Michigan Tool Co., 7171 *E. McNichols Rd., Detroit* 12, *Mich.*—20 *page booklet*—Double-reduction speed reducers in ratios ranging from 75:1 to 4900:1 are covered in Bulletin CD-230. Specifications are arranged in a convenient chart form, making the selection of a reducer of the exact capacity, type, and ratio, a simple matter.

Circle 528 on Page 17

LOOK... NO HANDS!



Die Rod Headers

Cold Heading Equipment Div., Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.—8 *page bulletin*—Three types of open die rod headers are described in Bulletin 866-A-3. Data on production features, operation, blank handling, punches and dies, heading units, and drives are given. Illustrative examples of parts that can be produced by each of the headers are included.

Circle 529 on Page 17

Meters and Controls

Bailey Meter Co., 1050 *Ivanhoe Rd., Cleveland* 10, *Ohio*—8 *page pamphlet*—Instruments for transmitting, recording, indicating and controlling are described in Bulletin G15-1. Dimensions and applications are given and a chart for obtaining detailed information on any of the various components is also included.

Circle 530 on Page 17

Indicator Instruments

Hagan Chemicals & Controls Inc., 323 *Fourth Ave., Pittsburgh* 22, *Pa.* — 12 *page bulletin* — Instruments which measure draft, pressure, differential gas pressure, and temperature; or are suitable as receivers with pneumatic transmitters for indicating flow, liquid level, and other process variables are described in Bulletin MSP-121. Diaphragm, bellows, and helix type units are covered, and dimensions noted.

Circle 531 on Page 17

Control Tubing

Crescent Insulated Wire & Cable Co., Trenton 5, *N. J.*—10 *page bulletin*—Crescent Armored Multitube, a system of installing instrumentation and control tubing, is described in Bulletin 356. Various types of tubing are explained and illustrated. A schematic drawing of a typical system is included. Data on standard construction of tubing is also listed.

Circle 532 on Page 17

Automatic Packeting

Brown Filling Machine Co. Inc., Fitchburg, Mass.—8 *page bulletin*—Unit which automatically feeds, counts, wraps, seals, and codes items such as nails, screws, nuts, bolts, and washers is described. Specifications and features are noted. Other units which packet average and large hardware items are also covered.

Circle 533 on Page 17

Screw Conveyors & Feeders

Canton Stoker Corp., 300 *Andrew Place, S.W., Canton* 1, *Ohio*—4 *page pamphlet*—Flo-Tube screw conveyors which move or feed materials such as coal, sand, gravel, sawdust, wood chips, and chemicals at controlled rates from bins or piles are described in Bulletin 957. Illustrations of various applications are included.

Circle 534 on Page 17

Air Control Equipment

Perfecting Service Co., 332 *Atando Ave., Charlotte* 6, *N. C.*—12 *page booklet* — Equipment such as regulators, filters, lubricators, drain traps, and dehumidifiers is described in Bulletin 80. Specifications and design features of the various components are noted. Also covered are accessories, hose fittings, and extra parts.

Circle 535 on Page 17

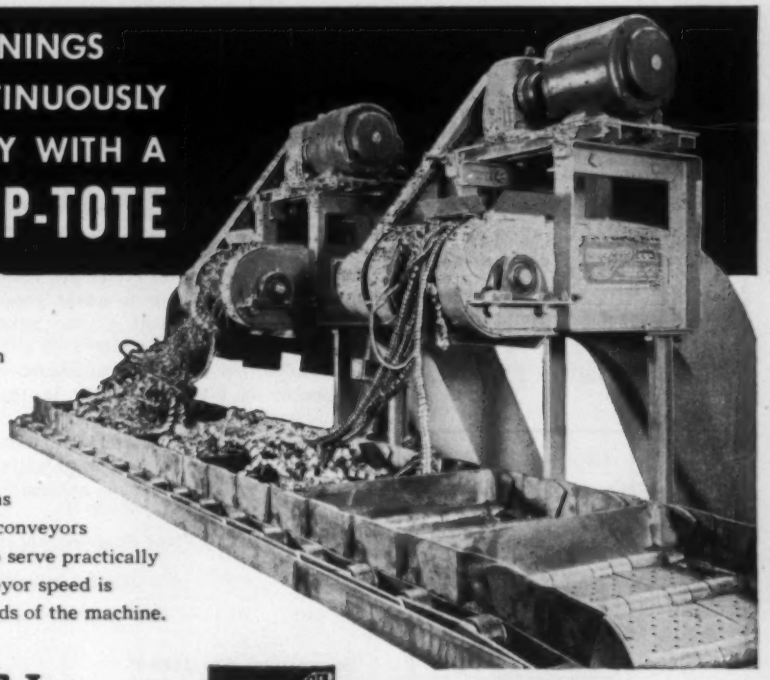
Rust Prevention

Marvellum Co., Appleton St., Holyoke, Mass.—6 *page pamphlet*—Packaging paper which prevents corrosion of ferrous metal parts is discussed. Design of the material is explained, and types of applications noted. A chart listing different grades of paper for various requirements is included.

Circle 536 on Page 17

REMOVE CHIPS, TURNINGS AND BORINGS CONTINUOUSLY AND AUTOMATICALLY WITH A

MAY-FRAN CHIP-TOTE



That's right! The May-Fran CHIP-TOTE permits the continuous operation of machine tools by eliminating down-time for scrap removal . . . skilled workers stay on the job . . . production increases by as much as 20%! Versatile CHIP-TOTE conveyors are available in a wide range of sizes to serve practically any type or size of machine tool. Conveyor speed is adjusted to meet the scrap removal needs of the machine.

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Circle 708 on Page 17

MODEL LF-1

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Lineal Footage Counter

Connected to any Post DECITRON electronic counter, the lineal footage device provides accurate measurement of paper, wire, rope, sheeted products, etc.

If desired, a predetermined length can be "set" into a Post preset counter and when the lineal footage device reaches this length, a secondary circuit (i.e. a slitter or marker) can be activated.

Dependable, accurate, maintenance free. Varied "beam hole", or wheel size will permit fractional footage counting, if desired. Write for bulletin LF-1.

Decitron Electronics Products Division

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POST MACHINERY COMPANY

Beverly, Mass.

Circle 709 on Page 17

AUTOMATION problem forum

Readers with problems concerning systems, equipment or components for automated operations are invited to outline them to: The Editor, AUTOMATION, Penton Bldg., Cleveland 13, Ohio. Solution suggestions should refer to case number and title of the problem involved.

Case 1329-P
Assembling Gas Cartridges

. . . I would like to avail myself of your service relating to a specific problem we have. The problem: To place a cap and washer assembly (cap on top) in the counterbored neck of a shell. The shell is supported vertically (counterbore up) in an indexing table. The machine cycles 30 times per min. It pauses approximately 2 seconds per cycle (the actual indexing is quite rapid). The caps and washers are separate. The washers, a cork-neoprene mixture, are boiled in glycerin to increase their pliability. This practice is necessary and forms, perhaps, the crux of the problem. The glycerin is an oily-sticky substance which has a high coefficient of friction. We have found that a tumbling action will mate approximately 80 per cent of the caps and washers. The caps and washers may be placed in the counterbore of the shell separately or as an assembly, remembering, in either case, that the cap must be on top.

Further, the cyclic rate of the machine may be preset to exceed 40 cycles per minute if production reasons warrant it. However, we are mainly concerned with capping the shells at a rate of 30 cycles per minute. We are planning to adapt present sensing equipment at the next index position to probe each shell and determine, (a) if the cap and washer assembly is placed properly in the counterbore of the shell, and (b) if there is no cap and washer assembly. If either of these conditions prevails, the shell will be rejected automatically. . .

Ass't to Plant Superintendent

Suggestions For 1168-P
Conveyorized Storage

. . . With reference to the subject problem, I believe we could readily solve it for the reader. We have handled a number of similar ones, and our more than 30 years of experience in precisely this type of materials handling problems gives us the background necessary to its solution.

For example, we recently completed a far more complex, but basically similar, installation at General Electric's Central Warehouse near Louisville, Ky. A variety of packaged items had to be handled very flexibly to storage, direct to shipping, or from storage to shipping, in the sequences called for by a wide variety of orders.

The precise methods which could be used depend, of course, on many factors other than those mentioned by the reader. We will be happy to have our nearest branch office get in touch with him to discuss his problem and work out the best and most economic solution . . .

C. W. Johnson
Mechanical Handling Systems Inc.

♦

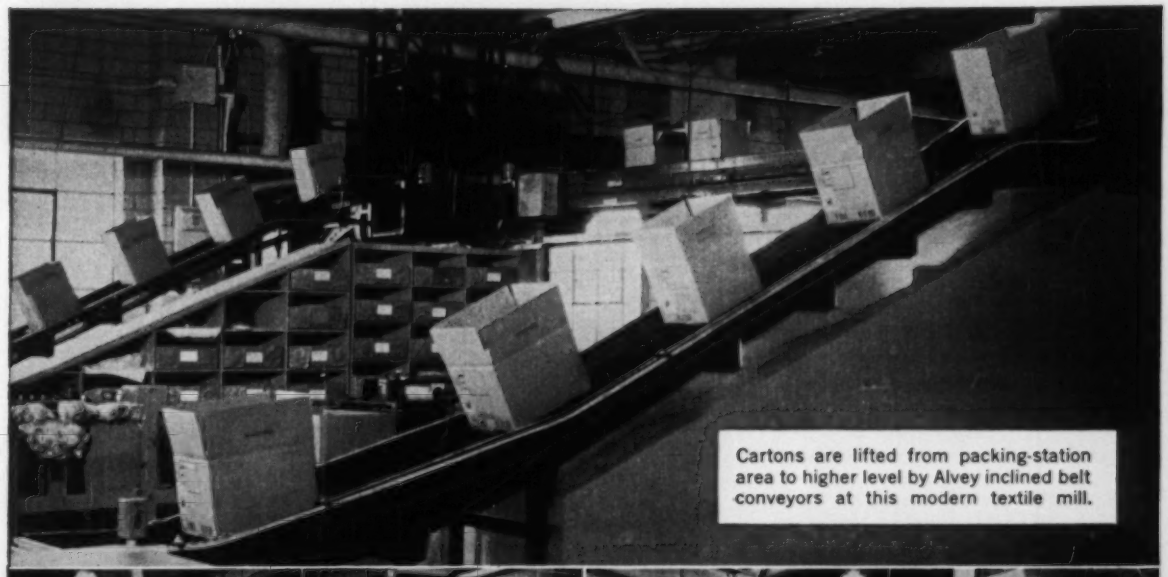
. . . Please find enclosed a write up that Ford Motor Co. furnished on one of their storage problems we were very successful in solving. We are designers and manufacturers of custom material handling systems and devices. Several of them have mostly concerned themselves with storage problems.

These storage problems have been of two types. One was a float point type of storage where accumulation of items prior to further processing had to be solved; the other type simply is automatic storage of items in a manner to allow automatic "calling for" of stored items in the amounts required for distribution, such as filling orders in case lots etc.

Size, weights, quantities, floor plan of space available, heights of ceilings and bays, whether air is available, power available and type, rate of production etc.; these are initial questions usually required to approach an automated storage problem.

If you can supply the above we would be pleased to give you a proposal on our approach . . .

Robert L. Bowdy
Michigan Production Engineering Co.



Cartons are lifted from packing-station area to higher level by Alvey inclined belt conveyors at this modern textile mill.

At left, cases are weighed and checked along spur branch lines, then moved onto belt conveyor en route to storage or shipping. "Traffic cop" (at right) assures smooth textile traffic flow by giving right-of-way to one packing case and halting the other until intersection is clear.

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Your profits just naturally *go up* . . . because your materials handling costs *go down* . . . when you install a completely integrated, Alvey-Engineered conveyor system. Bales . . . bolts . . . bobbins . . . doff boxes . . . rolls . . . cartons . . . all move smoothly, efficiently, safely, via Alvey. Thoroughly experienced in textile mill operations, Alvey engineers apply their training and skill in analyzing your plant operations. Then, they recommend a conveyor system that meets your needs.

Lower your handling costs, speed up production, and widen your profit margin . . . call in an Alvey engineer to study your individual problem. There's *no obligation* for *consultation!*

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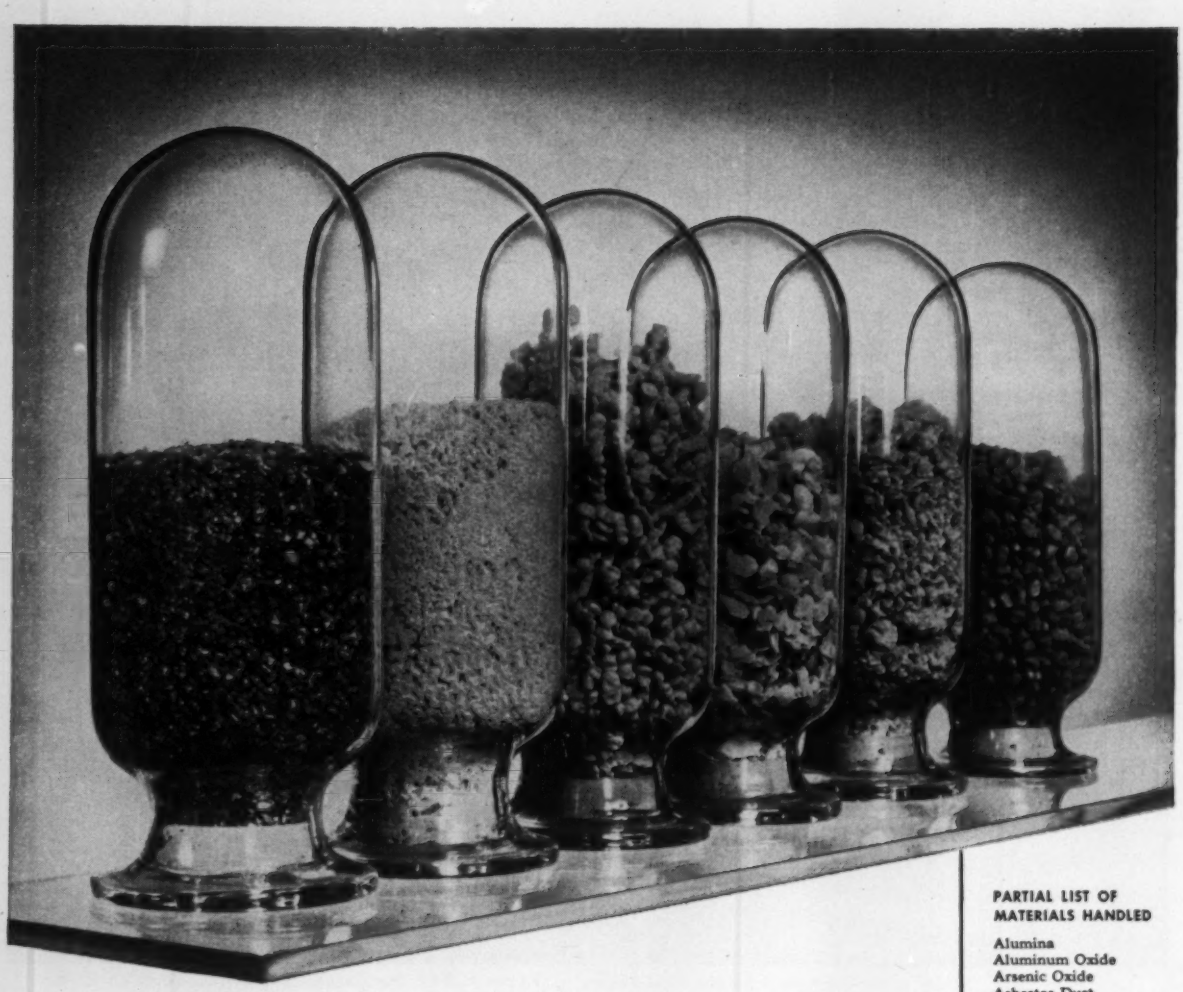
Circle 710 on Page 17



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Efficient, peak production is assured and at far lower operating costs than many other types of conveying systems, and your maintenance problems are at the minimum. Why not write to Fuller Company today—we'll be glad to send you descriptive literature showing you how Fuller solves many different problems in many types of plants.

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Alumina
Aluminum Oxide
Arsenic Oxide
Asbestos Dust
Barite
Bauxite
Bentonite
Borax
Calcium Carbonate
Carbon Black
Catalysts, Petroleum
Cement, Portland
Cement Raw Material
Chalk
Clays
Coal, pulverized
Detergent Powders
Diatomaceous Earth
Feeds, soft
Fertilizers
Flour
Flue Dusts
Fly Ash
Gypsum (raw or calcined)
Lime, pulverized
Malt
Ores, pulverized
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3756

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AUTOMATION abstracts

PROCESS CONTROL AUTOMATION

By W. W. SPENCER
Manager, Inspection Service
General Electric Co.

PROCESS CONTROL automation is that portion of automation that relates to the taking of measurements, processing the resulting data, and feeding back the results for control. This leaves process automation as the other side of the coin. Together, process automation and process control automation make up total automation.

Process control automation is growing rapidly in importance to all of us. Many experts agree that in the next ten years larger and larger amounts will be spent by industry for automatic control of manufacturing. In fact, by 1967, the amount being spent today will double and may very well triple. Of all manufacturing equipment dollars, 30 per cent will be spent for quality control equipment and 50 per cent for control equipment. Automation certainly is in the future.

Automation may be defined as continuous automatic production. There are, therefore, several steps from manual operation to full continuous automatic production. These steps start in the manual area and move through the mechanization area to automation. There will be many justified instances in our business where mechanization will be the nearest to automation some processes will come. Other processes will never be automated because we are unable to identify and define the specific quality criteria we should be measuring to produce automation. In the petrochemical industry, for example, we have a high degree of mechanization based on measurements like reaction temperature and pressure and material flow. However, due to our inability to identify accurately the criteria for product mix such as fuel oil, kerosene, and gasoline, and the quality criteria of the products, we cannot obtain feedback data for complete automation, which includes automatic process control.

Manufacturing Unlimited

In mechanical processing or manufacturing, however, we do not have this limitation. Instead, we have a unique opportunity to reach out toward process control automation, since we can clearly define and measure most of the quality criteria involved. The temptation, however, is to become trapped by thinking only of individual operations and not the over-all system. We must systematize any proposed mechanization and justify it only in the light of what is best for the entire process from raw material to finished product.

Economic benefits must accrue to the total process in order to justify whatever degree of automation we attempt. Sometimes these benefits come from cost reduction, increased production, better quality, or just being able to do something we could not do in any other way. Thus, a properly evaluated and systematized mechanized or automated process, including process control, can be profitable.

It has been found in some cases that process mechanization itself can be profitable, but is handicapped by little or no process control automation. As a result, process control has become a bottleneck. The truth of this is borne out by common knowledge of mechanized processes where material or product is removed from mechanized production for hand

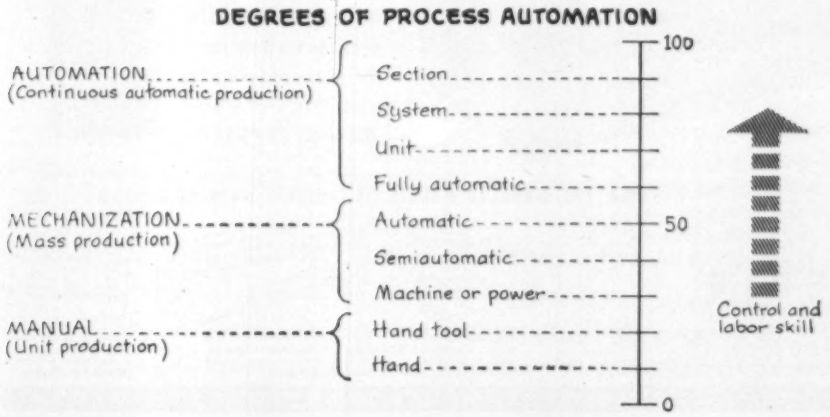


Fig. 1—Chart illustrates steps in progress of manufacturing operations from manual to automation levels. For comparison, numbers expressing degrees of automation have been assigned to each step. Note increased requirements for control and labor skill as automaticity increases.

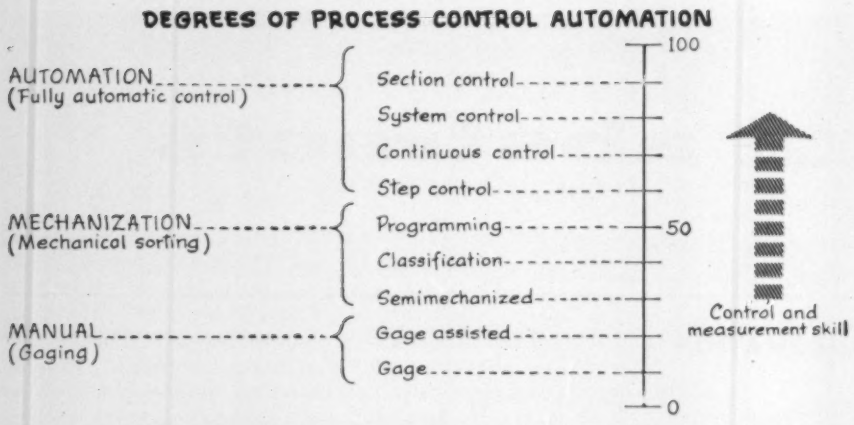


Fig. 2—This chart corresponds to chart of *Fig.* 1, but covers process control (inspection) aspect of manufacturing. Need for control and measurement skill increases with level of automation.

inspection and returned to the continuous operation. On one cylinder-block line for example, there are 28 process operations and eight process control operations. Of these, 24 process operations are mechanized above the hand stage but only one process control or inspection operation is in this category. This is a common situation.

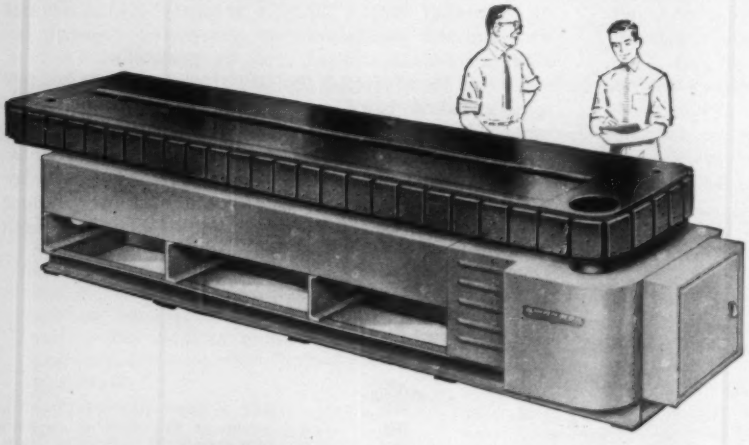
Yardstick Needed

It would be helpful to have some way of measuring our manufacturing level so that we might clearly and simply see the situation. Just how much of a bottleneck is process control because of a lack of mechanization? Since automation is an evolution, we should be able to set down the principal steps one climbs from bottom to top and match our attainment; i.e., how far up the ladder we have to climb for process mechanization and process control mechanization. *Fig.* 1 shows one way to depict the evolutionary ladder for process automation. Note as we progress up the ladder we require an increase in the amount of control and also labor skill.

Now to construct a corresponding ladder for process control automation, *Fig.* 2. Again, as in process automation, the start is in the manual area and progresses upward to full automation with increasing control or skill also in the upward direction.

By combining on a scaled grid the scale of progress for process automation, *Fig.* 1, with the scale

Plan your Special Purpose Machines AROUND SWANSON STANDARD INDEXING MACHINE CHASSIS



These standard units offer you a basic chassis for a wide range of special purpose and automatic machines. They give you substantial savings in cost *and eliminate much of your engineering time.*

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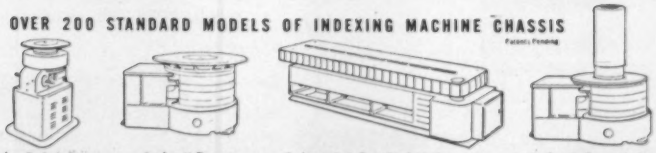

Series B & C Turret Index Models—for medium and light applications.

Series H Turret Index Models—for heavy duty applications.

Series L Auto-Tran Straight Line Indexing Chassis—for automatic or semi automatic assembly and processing operations.

Series K Turret Index Models—for heavy duty applications with center column tool mounting.

ENGINEERS AND BUILDERS OF SPECIAL AUTOMATIC MACHINES

for process control automation, *Fig.* 2, we can indicate the status of automation for both process and process control for any manufacturing cycle.

Such a display, *Fig.* 3, permits us to recognize the relationship between process and process control automation for each type of operation or point in the manufacturing cycle. It also permits us to average the difference between the two through numercial indexes. In the case shown in *Fig.* 3, for example, they would be process mechanization 48.6 average index number and process control mechanization 28.6 average index number. We clearly see by either relationship that there is a long way to go in automation—especially in process control automation. We can also use this diagram as a basis for determining our greatest need and the area of greatest potential improvement.

Aids to Analysis

Before proceeding to correct these unsatisfactory relationships, let us consider some other helpful tools for more completely analyzing how to take corrective action. First, answers to these questions should be found: 1. What are the quality characteristics that we can measure and use to control the operation? 2. Are these measurements properly organized in respect to the total manufacturing system? 3. Can we make available sensing elements for these measurements? 4. Will the sensing elements feed out usable signals for the control system? 5. Is this mechanization economical?

With this information in preliminary form at hand, we may construct four definitions applying to the specific operation we wish to upgrade through mechanization and automation. These are definitions of the measured quality criteria, the transducer or sensing device, the data processing, and the data feedback.

The next step is to break down the automation of our operation into progressive operational steps or

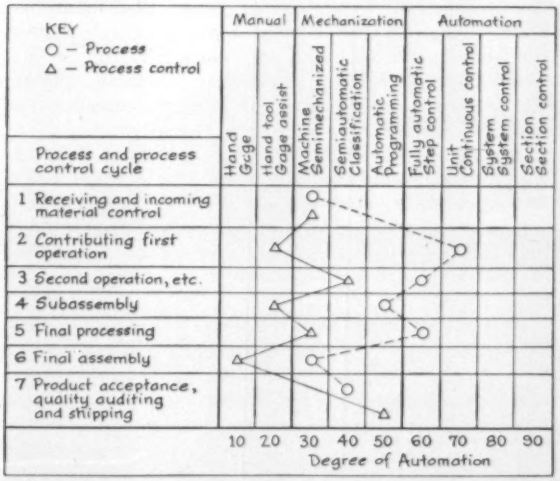

Fig. 3—Pictogram shows the status of automation of process and process control operations for a particular product. Degrees of automation shown are obtained from *Fig.* 1 and 2 for each element of cycle. Other products may require different cycle element listings.

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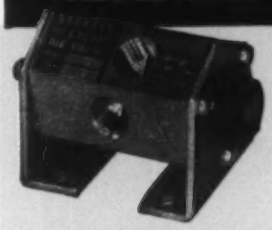

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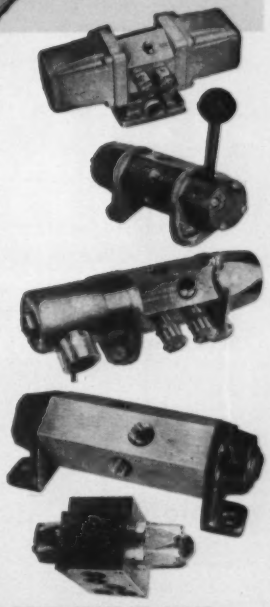

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elements and mesh these with our definitions and decide the degree of automation desirable for such elements. Finally we go back and review our first five questions and four definitions and integrate our total knowledge into one single answer—the degree of automation we should have for this operation. If we wish we can make this three-step analysis—questions, definitions, and operational elements—and from it determine a point for process control automation on our diagram. Thus, we find our total story of process control automation available to us in one pictogram. *Fig.* 3 will then be a complete diagram against which we can plan our future. At this point we should note any upgrading of the process automation beyond that shown which should cause us to re-evaluate our diagram.

The average example we have picked here may not be too far from any specific operation you may desire to analyze. Experts say that only 30 per cent of our industrial processes will be automated in the next ten years. Many of these processes will only be mechanized, as there will be no economic reason to do more; or perhaps technical knowhow will be lacking. In any event much can be done with what we have available today.

From a paper entitled, "This is Inspection Automation" presented at the Eleventh Annual Convention of the American Society for Quality Control in Detroit, May 1957.

DESIGN FOR MANUFACTURE

By KURT O. TECH
Vice president, Engineering
Cross Co.
Detroit, Mich.

IN RECENT YEARS considerable progress has been made in the ever increasing mechanization of productive processes in the manufacturing industries. This progress has been so rapid that a new word has been coined to describe it. It is called "Automation." Analysis shows that most of this progress has come about through the mechanization of material handling between machining, cleaning, gaging, and assembly operations. When we consider the costs of moving parts around a manufacturing plant it becomes quite clear that here a fertile field exists for the reduction of over-all production costs. It was recently estimated in one of our large electrical manufacturing concerns that material handling is responsible for about 25 per cent of the total cost of the product, and almost 40 per cent of the total labor cost.

The primary contribution of companies such as the Cross Company, has been in the developing of means to integrate machining and assembly operations with the material handling equipment required, so as to provide automatic processing. As we progress in this field there are two general areas of limitation which must be continually overcome as we advance. The first involves our own experience and the limits of our own technology. The second involves the limitations imposed by the design of the product being processed.

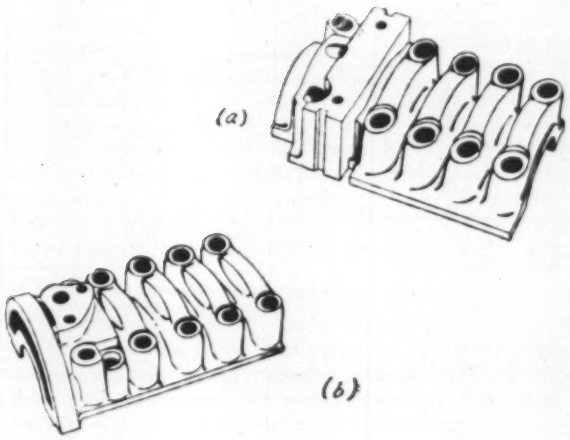


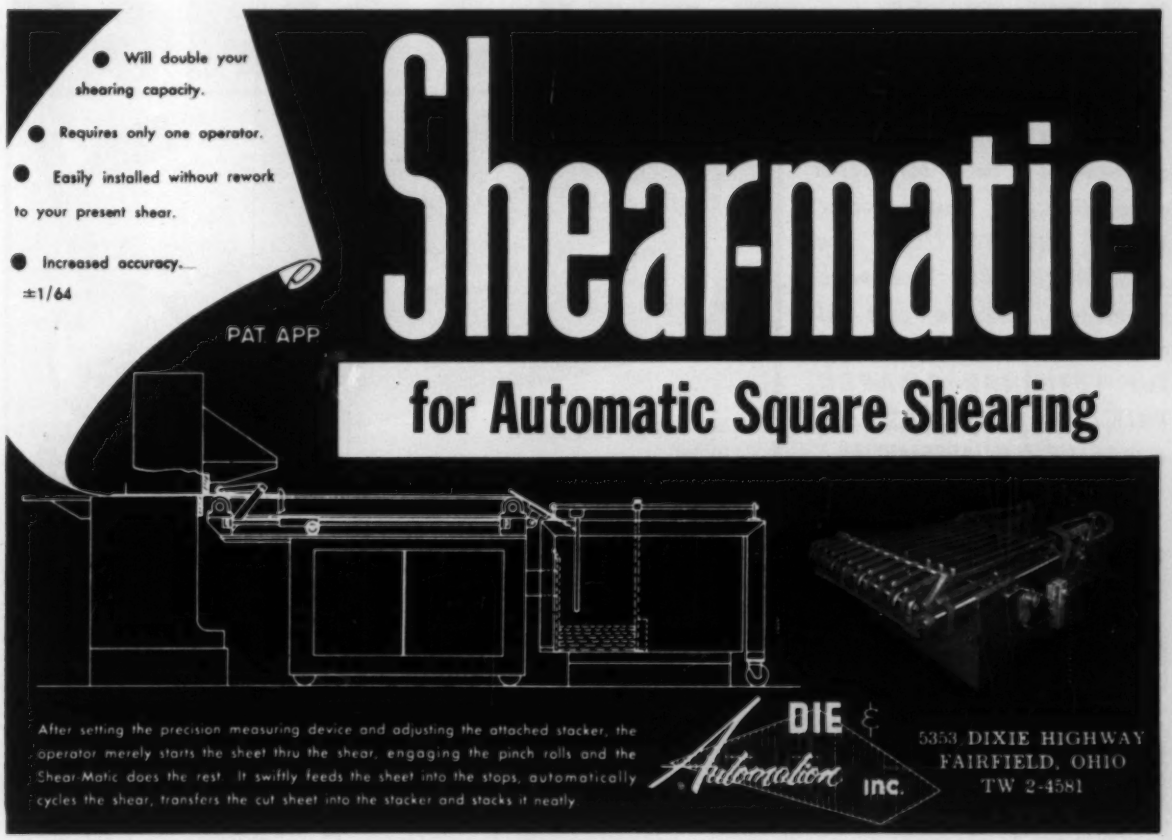
Fig. 1—Two types of crankshaft bearing cap assemblies. Design (a) is easier to handle for machining than design (b), as shown in Fig. 2 and 3.

Product designers generally are well aware of the effects which the design of a component can have on the cost because of the machining operations required. They know that surfaces which must be contour machined, rather than machined as planes, have increased cost. They are aware of the fact that angular holes, whether they be drilled, tapped, or bored, are more expensive to produce than horizontal or vertical holes. The fact that the greater number of different angles of holes which exist on a part increases the number of machining stations and the cost of capital equipment is also well known. Closer tolerances, I am sure, mean higher cost to most designers. Our experiences with the product designers of our customers indicate to us that they are coming more and more to appreciate the need for proper locating and clamping points because it assures them of a much better chance of having the part machined to drawing specifications.

Not nearly as well known or understood is the effect which the design of a part can have on costs through the handling, storing, and assembling of such parts. Many times insufficient consideration given to these problems in product design results in excessive costs in their manufacture. While much of our thinking at the present time regarding such designs is in the field of mass production, I believe that in the future such thinking will also have to be applied to the lower production industries.

Design for Handling

In the machining of parts in automation type machine tools it is necessary that provisions be included on the part, either as a part of its functional design or as an addition, to permit its being carried through a series of machining operations easily. This normally involves means of guiding and supporting the part between operations and means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for locating it accurately during successive machining operations.

If they are not provided on the part, and at times they are impossible to provide, it then becomes necessary for us to locate and clamp the part on a pallet which does provide such guiding and locating means. This pallet then carries the part through the machine for its various machining operations. After being unloaded at the far end it is necessary to return the pallet to the front of the machine to load another part. This adds considerably to the capital cost because the pallets and the pallet return mechanism are equipment which would not be required if the part could be guided through the machine by itself and located and clamped in each station.

Design for easier handling often presents the product designer real difficulties, but many times very slight differences in design can mean large differences in outlay for the capital equipment necessary to machine the parts. As an illustration of this, *Fig.* 1 is a drawing of two crankshaft bearing cap assemblies. Each of these assemblies carries all of the bearing caps for one engine in one casting. It is the normal practice in the automotive field to do all of the machining operations with the caps connected as shown, then saw them into five separate pieces in a final operation.

Parts of this type are usually made on an in-line transfer machine. In such a machine it is necessary to move these bearing cap assemblies between machining stations. The best way to do this is to slide

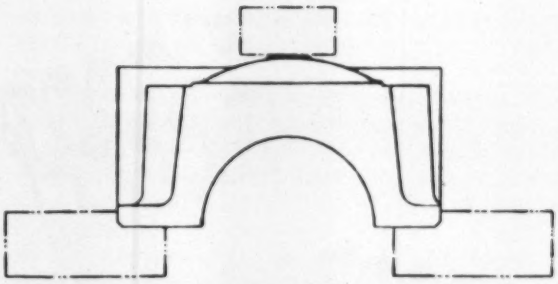

Fig. 2—Guide rail system for transferring bearing cap assemblies of *Fig.* 1 *(a)* design through an in-line transfer machine.

the part along on guide rails as is shown in *Fig.* 2. and 3. These illustrate both types of bearing cap assemblies. One is basically a block of cast iron with a single protrusion along the center of one side of the four intermediate caps. This protrusion contacts one of the three guide rails and permits very easy handling of the part. The other has a large circular head on the main bearing cap. Because of this it was impossible when designing a machine to provide a simple guide. The result was a considerably more complex transfer mechanism, involving a motion transverse to the direction of transfer, to support the part during its transfer. Naturally since it was a more complex mechanism it has been a more troublesome mechanism to maintain in the field. The cost of the equipment to manufacture 110 bearing caps of the first type per hour was 45 per cent greater than the cost of the equipment to

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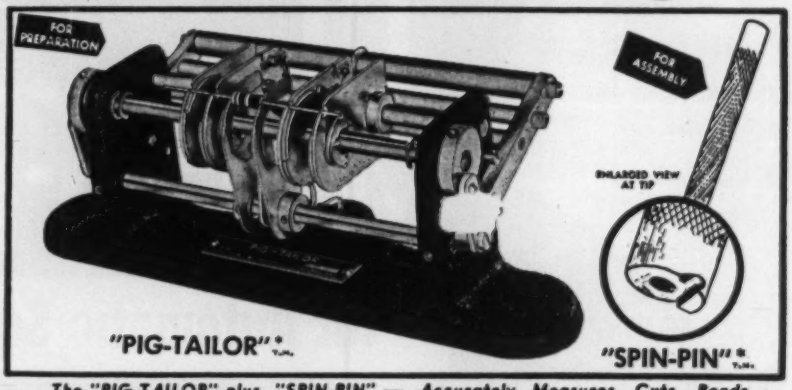

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manufacture 180 bearing caps of the second type per hour. Much of this additional cost can be attributed to the design of the latter bearing cap.

If thought had been given to this guiding problem by the product designers the bearing cap stud bosses on the intermediate bearing caps could have been raised 0.25 inch as shown in *Fig.* 3. This would have enabled us to use a simpler form of guiding and would have reduced the initial price of the machine and the maintenance costs of operating the machine.

Automatic Assembly

Automatic assembly of parts in the manufacturing field is becoming more and more common. Here too, the design of the various components to be assembled can have a tremendous effect on the cost of the equipment required and in many instances in determining whether or not the parts can be assembled automatically.

To outline for you some of the requirements of product design to help simplify automatic assembly, I would like to review the steps involved in an automatic assembly machine:

1. The basic part of the complete assembly must be carried through the machine.
2. This basic part must be accurately located at various assembly stations so that the components to be assembled to it can be brought into proper position.
3. The components to be assembled to the basic part must be properly oriented in the machine.
4. They must be distributed to the required point on the machine for assembly with the basic part.
5. They must be positioned accurately relative to the basic part while being assembled.

Along with these five steps I have just outlined there are five product requirements which will make automatic assembly considerably easier:

1. The basic part must have proper guiding surfaces accurate enough so that the part can be moved through the assembly machine without the use of complex transfer mechanisms.
2. The part must have accurate locating holes or surfaces so that it can be positioned properly in the various assembly stations.
3. If any of the parts must be positioned a certain way for assembly, external means to indicate

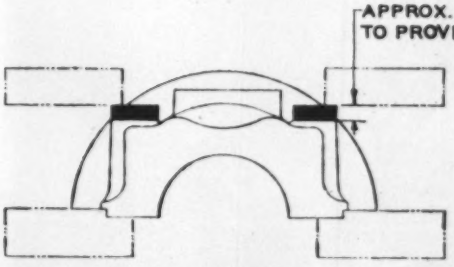
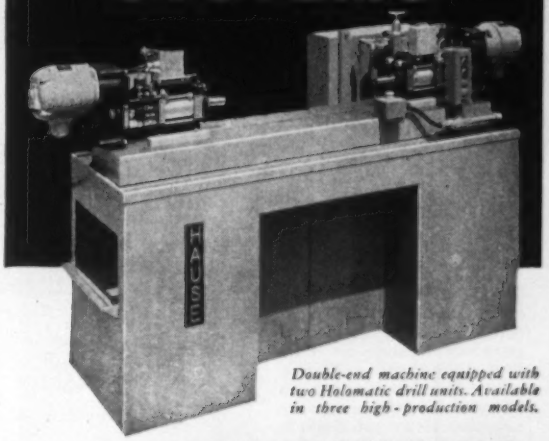


Fig. 3—Raising the stud bosses on bearing cap assemblies of *Fig.* 1 (b) design by 0.25 inch would permit simple guiding shown. Instead, a complicated support means is required because of the large circular head on the main bearing cap.

Holomatic
SYSTEMS



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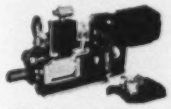
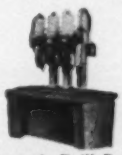


Model 24–Holomatic for Deep Hole Drilling



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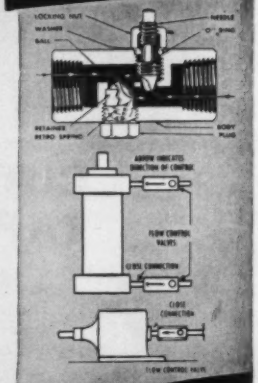

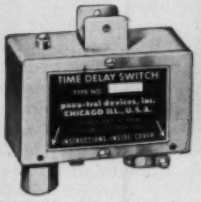

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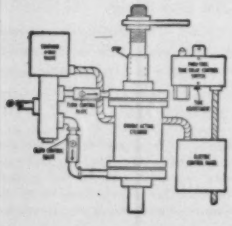

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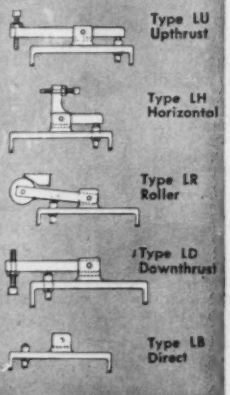

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from should be provided on the part for proper orientation.

4. Configuration of the various pieces assembled to the basic part should be such that they can be guided to the proper place for assembly without resorting to an overly complex distribution mechanism.

5. Part tolerances on these components must be held to permit the proper positioning relative to the major assembly. Sometimes it is necessary to hold part tolerances closer for automatic assembly purposes than is necessary in their final function in the product.

In addition to these five factors there are others which can have an effect. The location or grouping of the various components on the basic part is important from an accessibility standpoint. When automatic assembly is to be used it is necessary that clearance be allowed around the component to be assembled in its final position for mechanical assembly devices. We usually find that such devices are somewhat more bulky than a man's finger or hand. At best, close groupings can add stations to an automatic assembly machine; at worst, they can make automatic assembly impossible.

Angular assemblies are not necessarily extremely difficult to handle, but they are usually more expensive than horizontal assemblies. When the design of a product involves mounting of components at angles it is important that as many assembly operations as possible be handled at the same angle.

Location of screws on products being considered for automatic assembly can also have far reaching

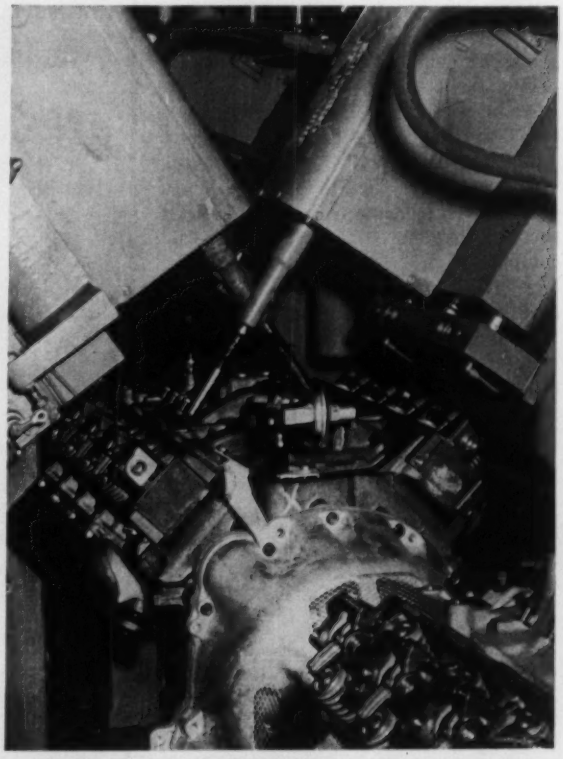

Fig. 4—Displacing bolt-hole patterns on opposite sides of engine blocks permits tightening all bolts in one station of this automatic engine assembly machine.

effects on cost. Screws which can very readily be inserted and tightened with hand tools can become virtually impossible to handle by automatic means. *Fig.* 4 illustrates a relatively close conditon which occurred on an engine assembly Transfer-matic which we recently manufactured. It would have been very possible for the screws on the opposite sides of the cylinder head to be directly in line, instead of missing closely as they did. This would then have involved two assembly stations and considerably greater cost than the one station which was required.

Our analysis of the manufacture of parts which must be machined and assembled indicates that if full consideration is given to the assembly problems during the design of the product, the machining and material handling can usually be done without difficulty. The design which is easily handled through assembly operations will obviously be easily handled through machining operations, and if the proper clearances are provided for assembly they will also be available for machining.

There are three strong influences on the design of any product: 1. The engineering or functional design of the product. 2. The appearance or styling of the product. 3. The manufacturing of the product.

It is my opinion that the manufacturing influence, taking into consideration the latest methods in manufacturing practice, has been accorded the least attention of the three. This has come about because of the difficulty of mechanical design engineers to be completely familiar with all of the possible variations in manufacturing practice. Those of us who are working daily on manufacturing problems and techniques have difficulty in keeping abreast. I could easily see where most product designers would have a job on their hands in keeping up-to-date with the technological progress in their own field.

I believe that the solution to a well balanced design will involve a three man team: The design engineer, the industrial designer, and the manufacturing engineer. It will be necessary for the manufacturing engineer to participate at the inception of the product design in order to do the most good. Decisions of the type which must be made involve a full consideration of the manufacturing objective, as well as the engineering objective. You cannot, however, compromise engineering in the interests of manufacturing. The right decisions will ease the manufacturing job and at the same time keep the functional operations which are the goals of the engineering designer. Obviously this will require men in all three fields who are well aware of the problems of the other fields so that design problems can be solved by discussions on a common ground.

From a paper entitled, "Designing for Easier Machining, Handling, and Assembly" presented at the 1957 *Design Engineering Conference of the American Society of Mechanical Engineers in New York, May* 1957.

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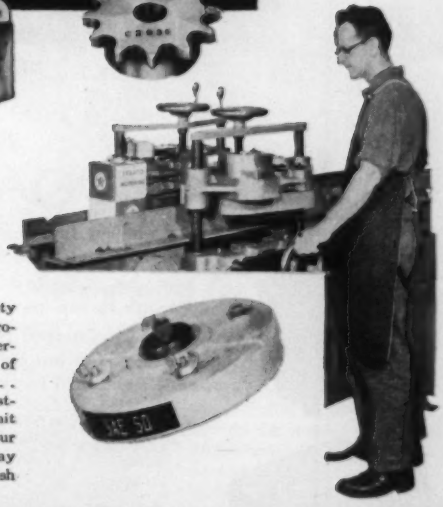

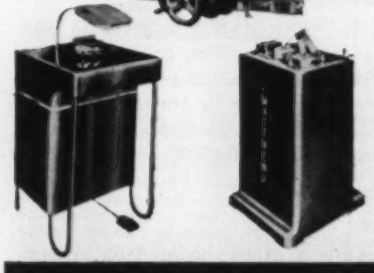

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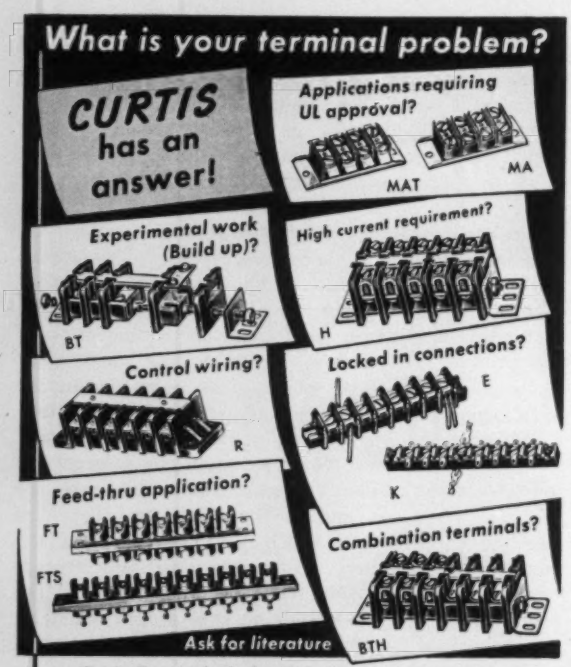

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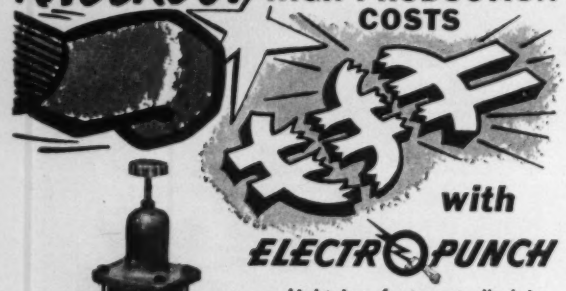

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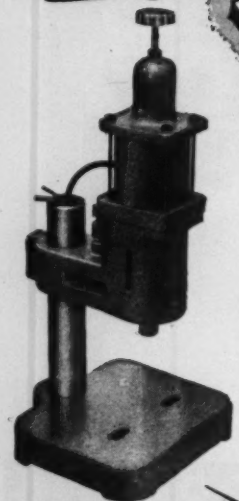

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SOLENOID-OPERATED PRODUCTION TOOLS

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AUTOMATION patents

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D.C.

AUTOMATIC NUT TAPPING MACHINE HAVING TOOL SPINDLES AND WORK HOLDERS MOVING IN A CIRCULAR PATH

A chute feeds polygonal nut blanks to a rotating circular carrier containing numerous holding chucks and tapping units. Motion of carrier about a horizontal axis causes nut blanks to be picked from chute and positioned in chucks which rotate in opposite directions to taps being fed into nut blanks. Patent 2,802,224 by Swan Hillman.

HORIZONTAL GYROFINISHING MACHINE AND METHOD

Article is transported into a cylinder rotating about a horizontal axis and containing abrasive material. Rotation of cylinder picks up abrasive which performs surface finishing operation on article. Patent 2,803,093 by Ward F. Diehl and Richard D. Purcell, assigned to General Motors Corp.

AUTOMATIC FEED FOR HOLLOW SET SCREWS

An oscillating hopper moves hollow set screws up an inclined track to a downward slide. Lugs on a rotating wheel enter hollow end of set screw and deposit it on a conveyor belt leading to a feed tube. Patent 2,803,377 by Charles A. Wilson, assigned to Standard Pressed Steel Co.

INDUCTION SOLDERING MACHINE

Articles are coated with a flux containing suspended particles of solder. The coated portions pass through a focused beam of radio frequency energy which causes solder to melt and form joint. Patent 2,803,731 by Herbert D. Coburn, assigned to Texas Instruments Inc.

PAGING MACHINE

A turntable contains a groove around its circumference into which are mounted a number of individual removable elements having signals recorded thereon. A reproducing head picks up the recorded signal as the turntable is rotated. Patent 2,804,507 by Richard R. Florac, assigned to Aircall Inc.

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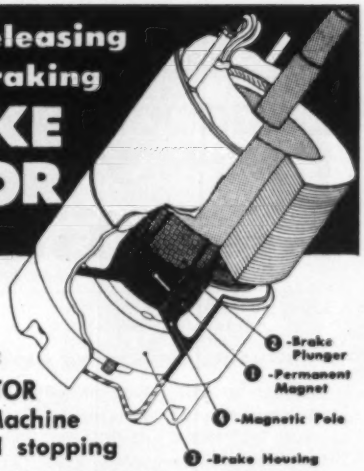

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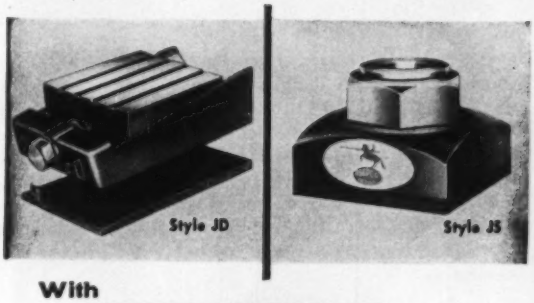

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Circle 727 on Page 17

AUTOMATION

new books

MAINTENANCE ENGINEERING HANDBOOK

Edited by L. C. Morrow, consulting editor, Factory Management and Maintenance; 1528 pages, 6 by 9 inches, illustrated, clothbound, published by McGraw-Hill Book Co. Inc., New York; available from AUTOMATION; $20.00 *postpaid.*

Increasing automaticity and the need for longer continuous production runs are placing greater emphasis on the maintenance function in the modern factory. In this handbook, 75 specialists present fundamental and advanced techniques needed to assure dependable operation of production facilities and to prolong the life of plant and equipment. Sections of the book discuss organization and administration of maintenance forces, details of mechanical and electrical maintenance, maintenance of buildings and service equipment, sanitation and corrosion control.

PLANT AND PROCESS DYNAMIC CHARACTERISTICS

Clothbound, 246 pages, 5½ by 8½ inches, illustrated; published by Academic Press Inc., New York; available from AUTOMATION; $8.80 *postpaid.*

Bound proceedings of a conference, sponsored by the Society of Instrument Technology, held at Cambridge, England, April 1956, to discuss the dynamics of processes. The analysis of closed loop systems requires a mathematical formulation for the measuring system, the regulating unit, the controller and the process; the first three elements are reasonably definable, but the process is less often amenable to mathematical definition. It is the purpose of this book to describe some current concepts, techniques and plant tests aimed at determining process dynamics.

TRANSISTORS HANDBOOK

By William D. Bevitt, transistor applications engineer, CBS-Hytron; 410 pages, 5½ by 8¼ inches, illustrated, clothbound, published by Prentice-Hall Inc., N. Y., available from AUTOMATION; $9.00 *postpaid.*

The early chapters of this practical reference book describe transistor types, measurement of their characteristics, and their properties and behavior in circuits. Free use is made of equivalent circuit representations, although the mathematics is held to a minimum. The last half of the book contains examples and analyses of practical circuits for audio and radio frequency amplifiers, oscillators, detectors, and complete radio and television receivers. Applications in computers, test sets, hearing aids and musical instruments are also covered. The appendix lists standards, characteristics and sources for commercial transistors.

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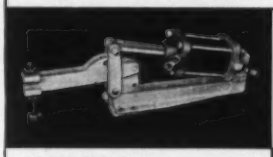

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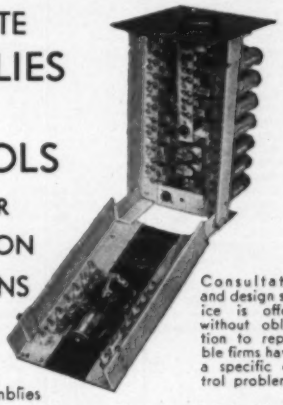

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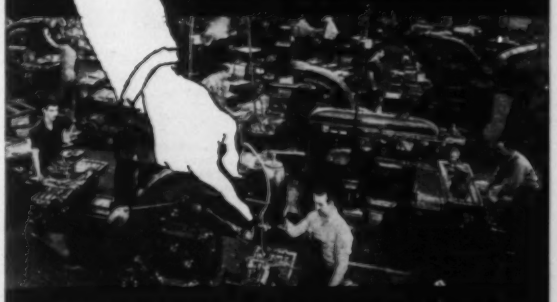

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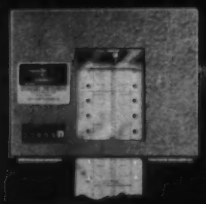

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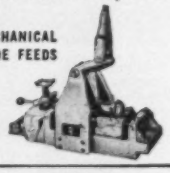

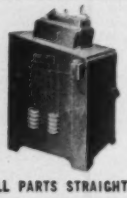

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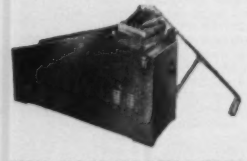

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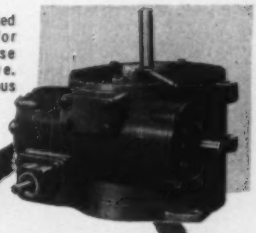

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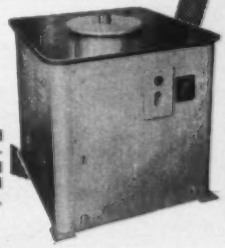

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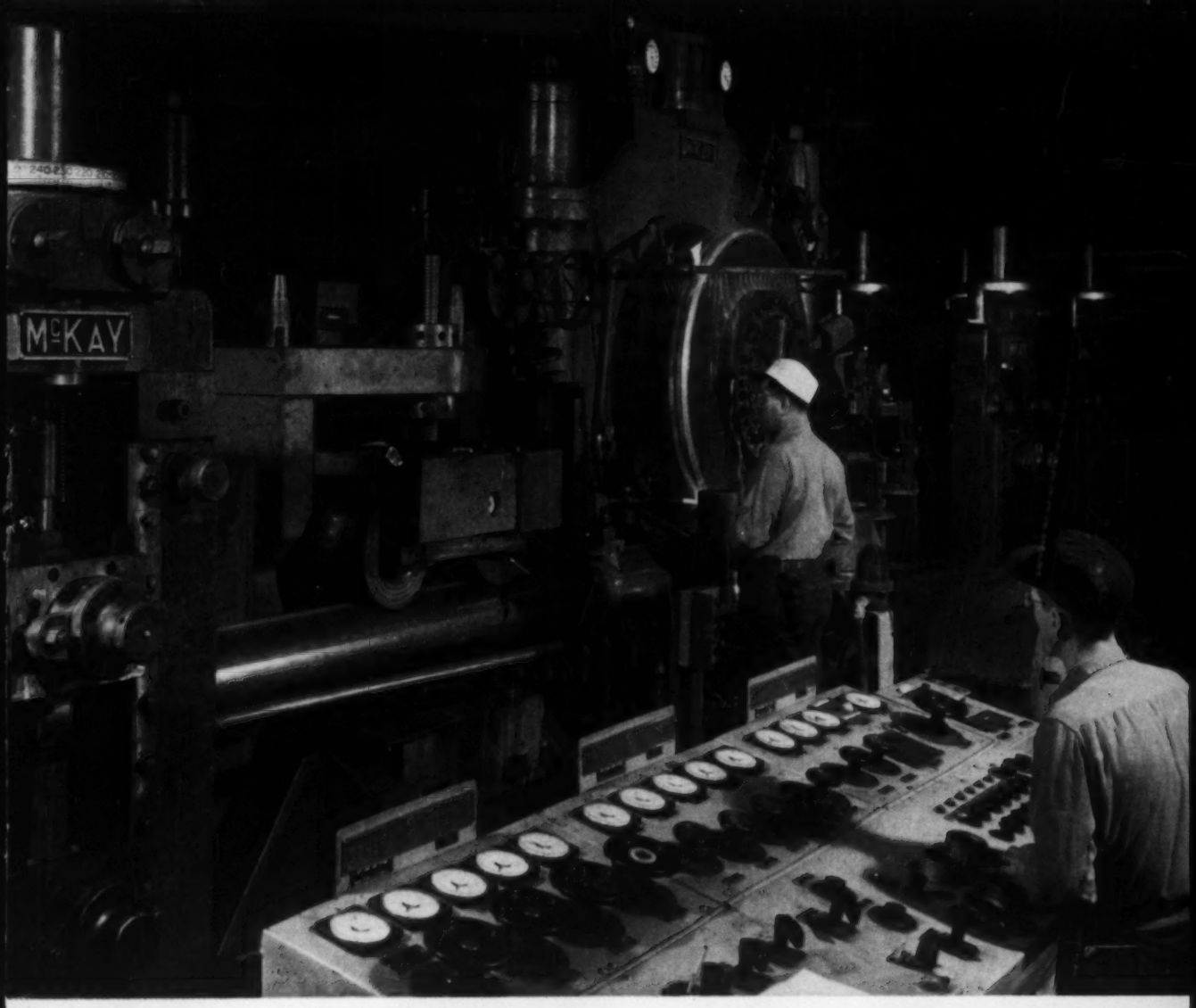

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Cutler-Hammer has pioneered the development of many vital electrical control components for aircraft. The dependable performance of this equipment in the best of today's military and commercial planes contributes directly to your security.

For your *Health*...

Dependable Cutler-Hammer Motor Control makes the modern water supply or sewage disposal plant a model of quiet efficiency and impressive cleanliness, a steadfast guardian of the public health.

For your *Comfort*...

Proper electric motor performance is the very heart of air conditioning and the leading manufacturers of such equipment, from small window-installed units to complete systems for huge buildings, use and recommend Cutler-Hammer Motor Control.

Electric motors and the control equipment which must direct and protect them have an astounding variety of jobs to do today. Modern aircraft and steel mills, for example, are poles apart in their needs. So are machine tools and air conditioning systems, sewage disposal plants and automobile assembly lines, oil well pumping and newspaper press drives. Each requires its own highly specialized control techniques and often control equipment just as highly specialized.

For sixty-five years Cutler-Hammer engineers have worked with the technical men of *all* industries on the specialized needs in motor control. In industry after industry they have been in the forefront of progress for decades, forever ahead with the leaders. It is logical that Cutler-Hammer Motor Control is so frequently the specified choice of both designers and users of specialized equipment where dependable performance is so important! And it is also most logical that you will find it pays to specify and insist on Cutler-Hammer whenever you order control.

Cutler-Hammer Three-Star Motor Control sets three new cost-cutting standards: installs easier, works better and lasts longer. Featured by leading machinery builders. Stocked for your convenience by your nearby Cutler-Hammer Distributor.

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